Issues in Engineering

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The original and two copies of a manuscript should be prepared on 8-1/2-in. (220-mm) by 11-in. (280-mm) white bond paper, typed double-spaced, and submitted to the Manager of Technical and Professional Publications, ASCE, 345 East 47th Street, New York, N.Y. 10017.

All papers and discussions are subjected to review and editing policies.

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DISCUSSION

Proc. Paper 16355

INFORMATION RETRIEVAL

The key words, abstract, and reference "cards" for each article in this Journal represent part of the ASCE participation in the EJC information retrieval plan. The retrieval data are placed herein so that each can be cut out, placed on a 3 × 5 card and given an accession number for the user's file. The accession number is then entered on key word cards so that the user can subsequently match key words to choose the articles he wishes. Details of this program were given in an August, 1962 article in CIVIL ENGINEERING, reprints of which are available on request to ASCE headquarters.

[a]Discussion period closed for this paper. Any other discussion received during this discussion period will be published in subsequent Journals.

16373 INVENTORIES, SURVEYS AND HISTORIC PRESERVATION

KEY WORDS: **Archaeology;** Engineering services; **Historic sites;** Inventories; **Preservation;** Professional engineering; Professional practice; Professional role; Professional societies; **Rehabilitation; Surveys**

ABSTRACT: The civil engineering profession is becoming increasingly involved in technical challenges associated with historic preservation. Inventories, surveys, and recording projects are uncovering more engineering and industrial sites and structures which can be adapted and reconstructed for a variety of uses. National organizations (such as the National Architectural and Engineering Record and the National Trust for Historic Preservation) work with local, state and regional groups in such surveys as well as in adaptive and other commercial studies. The Society for Industrial Archeology and similar organizations provide common meeting grounds for all people interested in such preservation work. Technically, financially, and personally, there are many rewards in meeting the challenges of professional preservation, restoration, rehabilitation, and adaptation.

REFERENCE: Hartman, J. Paul (Asst. Dean, College of Engrg., Univ. of Central Florida, Orlando, Fla. 32816), "Inventories, Surveys and Historic Preservation," *Issues in Engineering—Journal of Professional Activities,* ASCE, Vol. 107, No. EI3, **Proc. Paper 16373**, July, 1981, pp. 155-160

16400 PROFESSIONAL COMPETENCE

KEY WORDS: **Certification; Civil engineers;** Employment; **Engineering education; Engineering evaluation;** Engineering schools; Engineering societies; Engineering standards; **Ethics; Professional advancement;** Professional development; Professional engineering; **Professional practice;** Professional role; Registration; Students

ABSTRACT: The problems involved in maintaining professional competence and in preventing unethical and unprofessional work are examined. The profession attempts to guarantee competence in engineering fundamentals through the Engineer-in-Training (EIT) and Professional Engineer (PE) examinations. No certification program can prevent unethical or unprofessional work, which are ultimately prevented only by individual integrity, i.e., ethical competence. The profession's ethical standards should be part of the undergraduate engineering curriculum. Questions on ethics should be included on the EIT and PE examinations.

REFERENCE: Darr, George David (Student, Oregon State Univ., Corvallis, Oreg. 97331), "Professional Competence and the River of Knowledge," *Issues in Engineering—Journal of Professional Activities,* ASCE, Vol. 107, No. EI3, **Proc. Paper 16400**, July, 1981, pp. 161-163

16375 RADICAL CHANGE REQUIRES A FIRM FOUNDATION

KEY WORDS: **Contractors;** Efficiency; **Engineering personnel;** Industrial management; **Management planning; Organizing; Personnel management; Professional advancement;** Program evaluation; Project planning; Time factors

ABSTRACT: The methodolody is presented for the consolidation of two engineering departments in a major international design/contracting firm with over 600 employees. Four managers formed the planning team that developed a logical and systematic approach to improve efficiency of the organizational structure. A very participative form of management techniques was employed. The program was divided into two steps, planning and implementation. A full-time manager was employed to direct the implementation efforts. The consolidation occurred during a period of high work load, and successful completion of the projects underway held priority over the organizational changes.

REFERENCE: Kimmons, Robert L. (Vic Pres. and Div. Mgr., C.F. Braun & Co., Murray Hill, N.J. 07974; formerly Vice Pres. of Engrg., A.G. McKee & Co., Cleveland, Ohio), "Radical Change Requires a Firm Foundation," *Issues in Engineering—Journal of Professional Activities,* ASCE, Vol. 107, No. EI3, **Proc. Paper 16375**, July, 1981, pp. 165-173

16402 INDIVIDUAL DEVELOPMENT IN MATRIX ORGANIZATION

KEY WORDS: Consulting engineers; Efficiency; Employees; Engineering personnel; **Industrial management; Management systems; Organization theory; Personnel management;** Professional advancement; **Professional development;** Professional personnel

ABSTRACT: A matrix organization provides the structure for an engineer to develop both technical and managerial skills on a variety of assignments. This organization allows the firm to conduct an extensive on-the-job training program by moving the engineer into and out of different work teams. Movement of engineers helps to develop engineers who are exposed to all aspects of the firm's practice and helps the individual and the firm to evaluate the effective placement of the individual. In a true matrix organization, teams are formed and disbanded to meet the work requirements. Engineers have an opportunity to see various manager's styles and leadership characteristics, to determine which produces the best results, and to develop their own skills. Negative points of the matrix organization are also reviewed.

REFERENCE: Allen, H. Cecil (Vice Pres., Chf. Civ. Engrg., Turner Collie & Braden Inc., P.O. Box 13089, Houston, Tex. 77019), "Individual Development in Matrix Organization," *Issues in Engineering—Journal of Professional Activities,* ASCE, Vol. 107, No. EI3, **Proc. Paper 16402**, July, 1981, pp. 175-184

16370 ENGINEERING ETHICS: A UNIVERSITY COURSE

KEY WORDS: **Curricula; Engineering education;** Engineering societies; **Ethics; Instruction;** Planning; **Professional engineering;** Professional practice; **Students; Universities**

ABSTRACT: Ethics and ethical decisions pertaining to engineering practice can be taught as an elective or required undergraduate course. A case study is proposed utilizing sample cases. This utilizes analyses of assigned cases, oral presentations, written analyses, outside speakers, interviews with practicing engineers, and videotapes as a means of exposing the students to actual conditions encountered in practice. Procedures of conducting, methods of grading, and methods of evaluation of a typical course are included. Recommendations are included for planning such a course.

REFERENCE: Hassler, Paul C. (Prof. of Civ. Engrg. and Asst. Dean, The Univ. of Texas at El Paso, El Paso, Tex. 79968), "Engineering Ethics: A University Course," *Issues in Engineering—Journal of Professional Activities,* ASCE, Vol. 107, No. EI3, **Proc. Paper 16370**, July, 1981, pp. 185-191

16378 ENGINEERING: ANSWERS FOR THE 1980s

KEY WORDS: Accountability; Corporations; Engineering; Engineers; Future trends; **Innovation;** Political factors; **Productivity; Professional engineering; Professional role;** Resources; Responsibility; **Technology**

ABSTRACT: The innovation and productivity of professional engineers is constrained by politics, corporate policies and professional disunity as well (like OSHA, EPA and CPSC) answered for public safety. The society in which the engineer serves grows more complex as populations increase and as technology improves. These conditions pose technological challenges for the 1980s which are of ever increasing magnitude and which affect our free enterprise system and political freedoms. These challenges are addressed and solutions are suggested, listing goals the profession might consider if it chooses to engage in the societal leadership only it is capable of supplying. A discussion of professional accountability versus corporate responsibility and patent protection is included. Additionally, whether the growth of regulatory agencies like OSHA, EPA and CPSC were answers to the challenges of the 1970s is explored.

REFERENCE: Pletta, Dan H. (Univ. Distinguished Prof. Emeritus, Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24061), "Engineering: Answers for the 1980s," *Issues in Engineering—Journal of Professional Activities,* ASCE, Vol. 107, No. EI3, **Proc. Paper 16378**, July, 1981, pp. 193-204

16371 PROFESSIONALISM AND BUILDING SYSTEMS

KEY WORDS: Building design; **Building systems;** Consulting engineers; Consulting services; **Employees; Professional engineering;** Professional personnel; Professional practice; **Small structures; Standardization; Structural design**

ABSTRACT: Building systems that are designed, produced and marketed by companies are taking over a large share of the low-rise nonresidential market. These companies employ in-house structural engineers to design and research their systems. Work that was once performed by consulting structural engineers on a building-by-building basis is now done by the manufacturers' engineering staffs on systems that are sold repetitively. This trend has cut into the traditional role of the consultant. It also is widening the rift between those engineers who work directly for clients (so-called "design professionals") and those who design a product for an employer. Is one more professional than the other? The question is not new, but it has taken on a new twist lately, primarily in the field of standardized building systems. Some of the prevailing attitudes in this quarrel are examined, and an attempt is made to explain these attitudes in terms of design philosophy, economics and human nature.

REFERENCE: Ellifritt, Duane S. (Dir. of Engrg. and Research, Metal Building Manufactures Assoc., 1230 Keith Building, Cleveland, Ohio 44115), "Professionalism and Building Systems," *Issues in Engineering—Journal of Professional Activities,* ASCE, Vol. 107, No. EI3, **Proc. Paper 16371,** July, 1981, pp. 205-211

16399 ASCE AND CONTROVERSIAL TECHNICAL ISSUES

KEY WORDS: **ASCE (Professional Objectives); Civil engineers; Daniel W. Mead Prize for Students;** Legislation; **Professional engineering; Professional practice; Professional role;** Public benefits; **Public policy;** Technology

ABSTRACT: Civil Engineers have earned the responsibility of protecting, informing, and advising the public on controversial issues related to their field. Civil Engineers can best serve society in this capacity through the united voice of the American Society of Civil Engineers (ASCE). As a group, this professional organization can influence public policy, resulting in the most beneficial outcome for society. Society needs to be protected from hazards, informed on issues that concern the well being of the public, and advised on the possible alternatives concerning controversial issues. Civil engineers are in the best positions to perform these duties due to their technical background and their experience in serving the general public.

REFERENCE: Ruppert, Melissa (Pres. ASCE Student Chapter and Sr., Dept. of Civ. Engrg., Louisiana Tech Univ. Ruston, La. 71270), "The Role of the American Society of Civil Engineers in Influencing Public Policy on Controversial Technical Issues," *Issues in Engineering—Journal of Professional Activities,* ASCE, Vol. 107, No. EI3, **Proc. Paper 16399**, July, 1981, pp. 213-216

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Inventories, Surveys and Historic Preservation[a]

By J. Paul Hartman,[1] M. ASCE

Introduction

In the past few decades there has been increasing awareness within much of the United States and the world with respect to the physical remnants of our cultural and technological heritage. The National Trust for Historic Preservation which was chartered in 1949 has now grown to over 170,000 members. In addition, there are now regional, state, and local preservation offices and districts. There is increasing interest in responsible recording and preservation of important extant remnants of the past. Along with this awareness which initially was focused on architectural works, there is now more interest in the industrial and engineering facets of this heritage. Park districts have been formed for the Chesapeake and Ohio Canal, for the entire industrial district of Lowell, Mass. and for other local, regional, and national engineering and industrial sites.

The impact of this increased awareness on the engineering profession has been manifold:

1. Engineering history and heritage groups find additional interest and support from other groups as they seek engineering artifacts.
2. Scholars and academicians are delving more and more into engineering and industrial records as they trace technological growth and development.
3. Tourists and travelers are finding more and more historic sites devoted to early engineering and industrial developments, and are more aware of our technological heritage.
4. Preservation and development groups interested in preserving, adapting, recording, or modifying historic engineering works are seeking assistance from qualified professionals in technical areas which are unique and challenging.

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[a]Presented at the October 27–31, 1980, ASCE Convention and Exposition held at Hollywood, Fla. (Preprint 80-674).

[1]Asst. Dean, College of Engrg., Univ. of Central Florida, Orlando, Fla. 32816.

Note.—Discussion open until December 1, 1981. To extend the closing date one month, a written request must be filed with the Manager of Technical and Professional Publications, ASCE. Manuscript was submitted for review for possible publication on December 30, 1980. This paper is part of the Issues in Engineering—Journal of Professional Activities, Proceedings of the American Society of Civil Engineers, ©ASCE, Vol. 107, No. EI3, July, 1981. ISSN 0191-3271/81/0003-0155/$01.00.

Engineering Inventories and Surveys

In 1964, the ASCE established a History and Heritage Committee which began efforts to identify civil engineering landmarks and publish material of historic interest to the civil engineering profession. This early interest in engineering and technological history resulted in the formation in 1969 of the Historic American Engineering Record (HAER) within the national Park Service. The HAER was closely related to the Historic American Buildings Survey (HABS) which was organized in 1933. HABS for some years had been involved in industrial surveys and generated an interest in such surveys within the engineering community, as well as the general public. In 1971, the American Society of Mechanical Engineers (ASME) also formed a History and Heritage Committee and actively supported the work of HAER.

Reorganization in 1978 placed HAER as a program within the National Architectural and Engineering Record (NAER), which is under the Associate Director for Cultural Programs within the Heritage Conservation Recreation Service (HCRS). The HCRS, which is in the Department of the Interior, is charged with responsibility for three program areas: (1) Cultural; (2) natural; and (3) recreational. Other HCRS divisions within the Cultural Programs area include: preservation policy, state plans and grants, interagency archeological services, technical preservation services, and the national register of historic places, in addition to the NAER.

To bring all these programs closer to the states and regions, HCRS has established seven regional offices within the United States, and an area office in Alaska. Since all these programs require liaison with local and state groups, it is hoped that these regional offices will be more effective than concentrating all programs in offices in Washington. A listing of HCRS offices is given in Appendix I.

Through the NAER, the NAER programs for inventorying, surveying, and recording historic engineering and industrial works. These are done on a shared-fund basis with professional engineering societies, state and local governments, historical societies, universities, and preservation groups. The Record also works closely with the Smithsonian Institution, as well as with other historic organizations throughout the United States.

The recording programs operate primarily through two types of surveys: the regional survey determined by geographic or political boundaries, and the industrial survey, determined by a specific industry, and perhaps, its complementary industries. The regional survey can either be of an inventory type—identifying extant engineering and industrial artifacts—or it can be a comprehensive survey, including more complete historic, photographic, and measured drawing recordings. Several states and area have had inventories, including North Carolina, Delaware, New England, Michigan, and Florida, while more comprehensive surveys have been done in the Mohawk-Hudson area of New York, as well as with the textile mills in the New England area. A city inventory for Cleveland was completed in 1978.

While an inventory generally seeks to locate whatever is available, a comprehensive survey is not undertaken unless more explicit criteria with respect to the merit of the structure, equipment, or industry are met. A listing of selected inventories and surveys is given in Appendix II.

Each state now has a State Historic Preservation Office (SHPO) and local and state projects devoted to historic inventories, surveys, and preservation efforts should be coordinated by the local SHPO. This state office then works with the regional HCRS office to obtain matching funds.

Inventories and surveys are supervised by qualified professionals who use a variety of mechanisms to uncover and record works of historic significance. Some surveys use a block-by-block photographing technique, later tied into topographic or other historical maps. Factual information can be obtained from courthouse records, newspapers, and industry archives (if available). The "well-known" local historic industry can often turn out to have a minimum of formal information available. Although such data is not of major importance for an inventory, it is important for a comprehensive survey, especially for land use and adaptive planning purposes. Inventories, surveys, and recording projects can be scheduled on a continuing basis, or on a short-term basis such as over a summer.

Occasionally engineering students have been employed on summer recording and survey teams, but the majority of students working in these areas come from architectural and historical backgrounds. Many universities and colleges have included formal coursework in preservation-oriented fields, and students in such programs naturally migrate into these summer jobs, and then into full-time professional employment. The National Trust newspaper, *Preservation News*, carries advertisements for employment in surveys, as well as preservation planning work.

Societies: Society for History of Technology (SHOT) and Society for Industrial Archeology (SIA)

Engineers interested in following the progress of inventories, surveys, and historic preservation would be advised to support through membership the National Trust for Historic Preservation, and also the SIA.

With the great growth in engineering enrollments after World War II, as well as the exponential increase in technological development, there was increased interest in the historical aspects of this growth, as well as the interface between technology and culture. In the American Society for Engineering Education (ASEE), the liberal studies division was comprised of a diligent group of humanists, historians, and other nonengineers who were teaching engineering students or were involved in research on the technology-culture interface. Recognizing this common interest, a group of these individuals in 1958, founded SHOT. The objectives of SHOT were to promote the study of technological change, as well as increase the public understanding of the role of technology in civilization. SHOT is now an international organization with members throughout the world.

In its formative days, SHOT often had papers and presentations dealing with the work of individual scientists, engineers, and inventors. Papers also dealt with specific aspects of a technology or invention. Some individuals both within and without SHOT became more and more interested in specific physical remains of engineering and industrial sites. This included the types of structures and machinery, as well as their location, modifications, development, and demise. There was also an interest in actual archeological work—from the recording

and survey of a specific site to the assistance in its restoration/reconstruction.

In 1971, individuals interested in such work met to form (SIA), currently an international organization which "promotes the study of the physical survivals of our technological and industrial past." The membership of SIA is comprised of a broad spectrum, from engineers and technologists to preservationists, historians, architects, museum employees, archeologists, etc. The organization encourages everything from short courses to field trips, recording to research, education to publication, and preservation to adaptation of existing structures and equipment of significance in the history of industry, engineering, and technology. Many members are actively involved in preservation and adaptation efforts—locally or nationally.

Successful adaptation and preservation efforts throughout the United States have been well-publicized. Of specific note have been the Seattle Gas Works transformed into a park, the Chickering Piano Factory in Boston turned into apartments, and the Trolley Square shopping center in Salt Lake City. Many towns and cities have adapted industrial and commercial sites into shopping malls, parks and plazas, professional offices, and other uses. In some cases, the economic rehabilitation has been particularly noteworthy as, e.g., with the Quincy market area in downtown Boston.

SIA holds an annual meeting usually in spring at some location known for its industrial heritage (e.g., New York City, Troy, Pittsburgh, Baltimore, Detroit, and Lowell). Each meeting generally features one day of papers and two days of field trips. In addition, there are occasional regional meetings and field trips. The Society publishes a newsletter as well as a journal, *Industrial Archeology*. The SIA newsletter, in addition to National Trust Publications, is an excellent means of keeping abreast of the variety of activities taking place in historic engineering and industrial surveys and preservation work.

It should also be noted that in 1976 a group of SIA members specifically interested in adaptation and recording of such commercial establishments as theaters, motels, roadside America, etc. formed the Society for Commercial Archeology (SCA).

Conclusions

Despite or perhaps because of inflation, energy, and other economic pressures there is continuing and growing interest in historic preservation, responsibly and professionally done. The engineering profession will be called upon in many ways for appropriate assistance whether in the early stages of inventories and surveys or in later adaptation and development work.

There is much to be gained from such professional work. The technical problems are unique and challenging. The personal satisfaction gained from the rehabilitation or rejuvenation of historical works with attendant community benefits is immeasurable. And finally such preservation efforts can assist in making the general public more aware of our American engineering and industrial heritage.

Appendix I.—Heritage Conservation and Recreation Service Offices

HCRS Headquarters
440 G Street, N.W., Washington, D.C. 20243
(202) 343-5726

HCRS Northwest Regional Office
915 Second Avenue, Room 990, Seattle, Wash. 98174
(206) 442-4706

HCRS Pacific Southwest Regional Office
P.O. Box 36062, San Francisco, Calif. 94102
(415) 556-0182

HCRS Northeast Regional Office
600 Arch Street, Room 9510, Philadelphia, Pa. 19106
(215) 597-7990

HCRS Southeast Regional Office
75 Spring Street, Atlanta, Ga. 30303
(404) 221-4405

HCRS South Central Regional Office
5000 Marble Ave., N.E., Room 211, Albuquerque, N.M. 87110
(505) 766-3514

HCRS Mid-Continent Regional Office
P.O. Box 25387, Denver, Colo. 80225
(303) 234-6462

HCRS Lake Central Regional Office
Federal Building, Ann Arbor, Mich. 48107
(313) 668-2023

HCRS Alaska Area Office
1011 E. Tudor, Suite 297, Anchorage, Alaska 99503
(907) 277-1666

Appendix II.—List of Selected Inventories

Bluestone, D. M., ed., *Cleveland: An Inventory of Historic Engineering and Industrial Sites*, HAER, HCRS, United States Department of the Interior, 1978.

Comp, T. A., *New England: An Inventory of Historic Engineering and Industrial Sites*, HAER, National Park Service, United States Department of the Interior, 1974.

***Connecticut Historic Engineering Record: An Inventory of Early Industrial Sites and Engineering Artifacts*, History and Heritage Committee, Hartford Section, ASME, 1976.**

Gable, J. A., et al., *Long Island: An Inventory of Historic Engineering and Industrial Sites*, HAER, HCRS, United States Department of the Interior, 1978.

Glass, B. D., *North Carolina: An Inventory of Historic Engineering and Industrial Sites*, HAER, HCRS, United States Department of the Interior, 1978.

Hyde, C. K., and Abbott, D. B., *The Lower Peninsula of Michigan: An Inventory of Historic Engineering and Industrial Sites*, HAER, National Park Service, United States Department of the Interior, 1976.

Hyde, C. K., and Abbott, D. B., *The Upper Peninsula of Michigan: An Inventory of Historic Engineering and Industrial Sites*, HAER, National Park Service, United States Department of the Interior, 1974.

Kulik, G., and Bonham, J. C., *Rhode Island: An Inventory of Historic Engineering and Industrial Sites*, HAER, HCRS, United States Department of the Interior, 1978.

Molloy, P. M., *The Lower Merrimack River Valley: An Inventory of Historic Engineering and Industrial Sites*, HAER, National Park Service, United States Department of the Interior, 1976.

Thomas, S. *Delaware: An Inventory of Historic Engineering and Industrial Sites*, HAER, National Park Service, United States Department of the Interior, 1975.

Vogel, R. M., ed., *A Report of the Mohawk-Hudson Area Survey*, Smithsonian Institution Press, Washington, D.C., 1973.

Professional Competence and the River of Knowledge[a]

By George David Darr[1]

Introduction

All engineers should fear incompetence. With scientific knowledge doubling every 15 yr–20 yr, it is virtually impossible for an engineer to be completely current and, therefore, completely competent in all areas. Engineering knowledge is like the ever-changing world described by the Greek philosopher Heraclitus, in which, "You cannot step into the same river twice, for the second time it is not the same river." Or, as wittily amended by a successor, "You cannot step into the same river once, since it is changing while you step." The technical "river" changes so quickly that the engineer who fails to stay current almost guarantees his obsolescence, and the obsolete engineer imperils both the profession's prestige and the public's welfare.

While engineers have always been concerned with maintaining competence, the profession has trusted to individual integrity such matters as keeping current, and refusing assignments for which the engineer is not competent. The public, however, is becoming less and less willing to share this trust. It feels that since engineering work often has a direct bearing on public health and safety, maintaining competence is vital to its well-being. Consumer groups question the profession's ability to police itself, especially in light of the well-known reluctance of professionals to speak against each other. The political result has been calls for mandatory recertification, "proof" of maintained competence. The result within the profession has been a renewed focus on the problem, including an effort to establish the exact meaning of professional competence. If we examine the notion of competence closely, we find it has not only a technical component, but also an ethical component deserving greater attention.

[a]Recipient of the 1981 Daniel W. Mead Prize for Students.

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Note.—Discussion open until December 1, 1981. To extend the closing date one month, a written request must be filed with the Manager of Technical and Professional Publications, ASCE. Manuscript was submitted for review for possible publication on March 9, 1981. This paper is part of the Issues in Engineering—Journal of Professional Activities, Proceedings of the American Society of Civil Engineers, ©ASCE, Vol. 107, No. EI3, July, 1981. ISSN 0191-3271/81/0003-0161/$01.00.

Technical Competence

An engineer may achieve technical competence by two methods, i.e., training and experience, and at two levels, i.e., engineering fundamentals and specialties. Training is usually obtained through a program of taking technical courses at an accredited school. Experience is obtained through engineering practice, i.e., on the job. The Engineer-in-Training (EIT) and Professional Engineer (PE) examinations attempt to guarantee minimum competence in engineering fundamentals. Whereas engineering experience is a prerequisite to taking the PE examination, assessing the quality of this experience is a more subjective process. Still, it seems fair to say that the profession tries to ensure that all licensed professionals were, at least once in their careers, well-grounded in the fundamental engineering subjects.

Competence at the specialty level is another matter. Unlike the fundamentals, which change relatively slowly, current practices in the specialty fields change constantly. Staying current requires conscientious effort. While not all engineers may want or need to make this effort, some distinction should be made between those who do and those who don't. Perhaps an example will clarify this point. We might trust a general practitioner in medicine to remove our appendix, but for brain surgery we'd certainly go to a brain surgeon, and we'd want some reliable means of telling one doctor from the other. Similarly, in engineering some distinction should be made between generalist and specialist, perhaps through special certification or through programs such as that implemented by the Florida Engineering Society to recognize continued professional development (1). Just as land surveying is singled out in many states as an engineering specialty requiring special competence, the imposition of certification requirements in other specialty areas seems inevitable. It seems desirable to establish a uniform program within the profession rather than having it imposed by outside interest groups.

Up to this point, civil engineers have strongly preferred voluntary professional development to mandatory recertification. A discussion of the potential problems associated with mandatory recertification is beyond the scope of this paper. Nevertheless, it is important to realize that academic credentials, professional accreditation, and recertification are no insurance against unethical and unprofessional work. These are ultimately prevented only by individual integrity, i.e., ethical conduct, the second component of engineering competence. In fact, if ethical competence is achieved, technical competence will result.

Ethical Competence

Ethical questions usually fall under one or more of three main categories, namely, questions of: (1) Right and wrong; (2) obligation or duty; and (3) desirability or worthwhileness. The ASCE Code of Ethics makes specific pronouncements in the first two categories to achieve a goal in the third category. Thus it is "right," e.g., for engineers to "perform services only in areas of their competence." And it is one's "duty" to strive "to increase the competence and prestige of the engineering profession." The expressed goals of the Code include advancing "the honor and dignity of the engineering profession" and "the advancement of human welfare."

Just as no legislature can create a law to cover every possible circumstance, neither is it possible for a Code of Ethics to prescribe a course of action for every situation. However, it is possible for every engineer to know his duties under the Code, and to know how State Licensing Boards have interpreted the Code in representative cases. It is also possible to include ethical questions on the EIT and PE examinations, thus requiring of all prospective engineers knowledge of the duties of their profession, which is at least the germ of ethical competence.

Obviously, mere knowledge of a Code of Ethics can not assure ethical behavior any more than possession of technical knowledge can guarantee that knowledge will be used. But if all engineers *know* what is expected of them, *know* the necessity of continued professional development, and *know* the penalties for attempting to perform services outside their areas of competence, these obligations are far more likely to be met.

Ethical training should be part of undergraduate engineering education. It is this writer's experience that most students take their obligations as engineers very seriously, and it seems likely that proper knowledge of these obligations at the outset of their careers would be beneficial both to them and to the profession. Although some of this training is already achieved through ASCE Student Chapter activities, a more formal program would reach all students. This program should include: (1) Discussion of the ASCE Code of Ethics; (2) positions taken by State Licensing Boards in representative cases; (3) opportunities and methods for continued professional development; and (4) exposure to the ethical problems created by increased world population and pollution, and by diminished energy, natural resource, and food supplies. Clearly, engineering schools can undertake the moral training of engineers only to a limited degree. Engineering schools can, however, ensure that students are aware of the standards their profession expects them to uphold, and can provide some guidance toward achieving these standards.

Conclusion

Technical knowledge is increasing so rapidly, no engineer can expect to maintain complete technical competence, especially in the specialty areas, without a conscientious, dedicated effort. While certification should be available to recognize differing levels of competence, the public's ultimate protection lies in the high standards of ethical competence demanded by the profession. Engineering schools should provide training in professional standards, and guidance toward their achievement. Ethical questions should be included on the EIT and PE examinations. If ethical competence is achieved, technical competence will follow. Only be frequent "steps into the river" can engineers achieve the high standards necessary to maintain the public trust.

Appendix.—Reference

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Radical Change Requires a Firm Foundation[a]

By Robert L. Kimmons,[1] F. ASCE

Introduction

Engineering organizations traditionally are monolithic in structure. Change occurs slowly if at all. The few changes made are sometimes for the wrong reasons.

The climate in which today's engineering offices operate is very different than the conditions existing only 30 yr ago. The pace is much faster and pressures are greater. Tremendous costs are involved in today's projects. The attendant high cost of money makes it imperative to minimize elasped time from the start to the finish of a project. Projects are more complex. Engineering work involving chemical or mechanical processes is more complicated. Material selection has become more difficult, more specialized. The maze of legal requirements and permits for safety, environment, and toxic substances make engineering, design, and construction more demanding.

The structure of our engineering organizations has frequently not responded to changes in the demands made on these organizations. A periodic analysis of the work output and the optimum way of performing that work is necessary. This will ensure the most effective utilization of our limited manpower.

Great gains in the use of electronic engineering tools have been achieved during the past few years. Computer solution of complicated technical problems has become commonplace. The use of electronic processors in making engineering drawings and in word processing has had impact on the organizational requirements.

J. D. Batten states (1)

> The aggressive manager is never satisfied with his organization. He realizes the need for flexibility, innovation and fluidity. He cannot countenance the stereotyped, hackneyed, inflexible organization that chains people to sterility and mediocrity. He recognizes the need for change and uses change

[a]Presented at the October 27-31, 1980, ASCE Convention and Exposition, held at Hollywood, Fla. (Preprint 80-682).

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constantly as a tool to strengthen his group, to stimulate the growth of individuals, to meet changing objectives, to keep the fat out.

This paper deals with the methodology used in the consolidation and reorganization of engineering departments of a large international design/construct firm. Based on the experience gained during this effort, certain criteria have been observed that may be generally applied. These criteria are first identified, and then specific commentaries are offered based on the experiences gained during implementation process.

Background

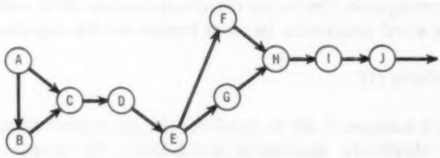
At the time the reorganization was authorized, there were two separate engineering organizations. Each dealt with a different segment of the process plant industry. The commission was to combine these two groups into one stronger organization that would be able to better serve an even broader spectrum of that industry. An early decision was made to take advantage of the impending changes to review the overall operation. Additional modifications could be made to increase operational effectiveness.

During the reorganization period the workload for the larger of the two groups was high and an active recruiting program was underway.

Reorganization Strategy

The first three weeks of the assignment were spent in solidifying the objectives and in developing an overall concept of how the reorganization should be *planned*. Design parameters of the new organization were formulated.

Once these parameters were established, a team would be picked to plan



Planning Activities

A–objectives and over–all concepts
B–design parameters
C–planning team members
D–work and work product analysis
E–organization structure
F–staffing
G–office layout
H–implementation plan
I–plan approval
J–adjustments to plan

FIG. 1.—Logic Diagram for Planning Organization Change

the organization. The team would conduct a detailed analysis of the work normally done by the current organizations. This information would be classified to aline services of a similar nature. Adjustments would be made to bring the classification into accord with the parameters established. The results would be the basis for the design of the new organizational structure.

A staffing analysis would then be done and alternative candidates would be considered for each of the key positions.

Next, the layout of the office work areas for the new organization could be started; and the implementation plan for the reorganization could be developed. This would be followed by the detailed schedule of implementation activities and the estimate of costs.

Because of the implications of this major change in operations, the entire program would have to be presented to corporate management for review and approval.

These steps defined the *planning strategy* for the reorganization. Definition of the *implementation strategy* would be developed along with the detailed plan, because it is dependent upon that plan.

For purposes of orientation, a logic diagram of the planning activities is shown in Fig. 1. Each activity will be discussed and observations resulting from the actual experience are made.

Objectives and Concepts

The objective of the reorganization was agreed upon:

> To *review* the current organizations and to *consolidate* similar functions in order to achieve improvements in efficiency without disrupting work in progress. To establish an organization which reduces layering of supervision.

Among the governing concepts for the new organization (1) A matrix organization will be used; task force execution of projects will be expanded; (2) future needs will be projected, evaluated, and the new organization designed accordingly; (3) "Dead spots" will be eliminated in communication channels for the new organization; (4) "team management" will be used where appropriate; (5) management positions will be established only where definite responsibility and accountability exist; (6) related work activities will be grouped and difficult and awkward interfaces minimized; (7) full recognition will be made of dual-ladder career progression in designing the organization; and (8) job classifications will be established in accordance with levels of responsibility.

All of the subsequent activities would be pursued to meet the established objective and to conform to the overall concepts listed.

Design Parameters

The new organization had to be designed to provide for anticipated growth. The two existing engineering groups together totaled 600 people—200 in the metallurgical group and about 400 in the hydrocarbon processing group. A 50% expansion was selected for the design strength of 900 people.

The basic building block of the new organization would be the engineering *section*. The section was defined as an organizational entity having a maximum strength of 50 people. This number is based upon personal experience over the past 30 yr as being the maximum number of people that a manager can effectively manage in an engineering organization realizing that the manager must really get to know each of these individuals, their capabilities, their strengths, their weaknesses, and their aspirations.

Above the section would be the engineering *department*. Also based upon experience, the department manager would have six sections reporting to him for optimum performance. This would give the department manager responsibility for 300 people at full design strength.

Using these initial guidelines, the design strength of 900 people would result in an organization of three departments of 300 each. A total of 18 sections of 50 people each could be accommodated.

Another important parameter was the avoidance of "assistant" manager positions at both the departmental and at the section level. This was deliberately done to assure a definite responsibility and accountability for each position. It allowed the resulting organization to be relatively broad and flat by eliminating intermediate layers of supervision.

Planning Team Members

The participation of the key managers of the future organization in the planning effort is highly desirable. As the tentative requirement for three departments had already been established, the leading candidates for the three department manager positions were chosen to join the vice president of engineering as members of the planning team.

Qualifications of the manager included a broad knowledge of operations in the two existing engineering groups, a personal acquaintance with a large number of the engineering personnel, and a willingness to devote extra time and effort to the planning activities. In addition, the fact that the individuals had very diverse backgrounds, experience, and personalities was significant to the success of the venture.

The participatory planning process and the necessary close association over a period of time with other members of the team led to a supportive interaction among the managers. This occurred despite very natural differences and conflicts at the beginning.

Work and Work Product Analysis

The four team members were each assigned a part of the existing organization to evaluate. Working with managers and supervisors in these groups, he compiled a listing of all of the services performed and the documents produced. This list was transferred to index cards where the individual work activity was listed along with the current group performing the work. Preceding and following work activities were identified to pinpoint interfaces. On index cards of another color, the documents produced were listed together with pertinent information as outlined previously. In this manner, several hundred cards were prepared to cover the work of the engineering groups.

Organization Structure

The index cards were then sorted into various piles containing like activities, like skills, and similar documents and areas requiring close interfaces. These piles were then successively integrated until only four piles remained. Each team member assumed responsibility for preparing an organization chart for one of these piles. During this period extensive use was made of a magnetic chart board to simplify making the necessary intermediate changes. And in order to obtain the three departments from the four piles of cards, the fourth deck was distributed among the three others.

The final overall organization chart was optimized through extensive interchange of ideas among the team members. The organization consisted of three departments, 17 sections, several subsections covering technical specialty areas, and certain technical positions for highly-skilled individuals acting as consultants.

Staffing

At this point, the team members responsible for developing the departmental organizations were confirmed as future managers for those respective departments.

Section managers were selected by the team with the department manager making the final selection after consultation with the other team members. Qualifications of the section managers included demonstrated management ability, continued management growth potential, attitude, communication skills, and a high evaluation of credibility in the new position, both from the standpoint of management and that of the personnel in the section.

A new organization chart was then drawn up showing the staffing of all management positions. All engineering personnel were assigned on paper to their new sections.

Office Layout

The office areas available to the new organization were identified. The index cards were alined to show work flow within the office. These, combined with the staffing levels determined previously, were used to prepare alternative layouts. Provisions were made for some early growth. A tentative plan was provided for ultimate growth plans. Layouts were revised and optimized before the final configuration was selected.

Implementation Plan

Based on the new organization and the office layout, the implementation plan was formalized. At this time, a project manager was named to head up the implementation of the reorganization. The project manager was made a full member of the planning team. The decision to utilize a project manager for implementation was probably more significant to the success of the work than any other decision made by the team. The extent of detailed planning required made it impractical for this function to be done on other than a full-time basis.

Support of all engineering personnel was deemed essential to obtaining proper acceptance of the new organization. Group meetings were called to explain the reasons for the changes. Each person in engineering would participate. In addition, key personnel from other departments would also receive a presentation covering pertinent information.

As a part of the overall implementation plan, necessary modifications and adjustments required for the existing systems and procedures were outlined.

All implementation activities were sequenced, and a milestone chart was prepared outlining key dates. The implementation schedule was developed. Finally, the cost estimate for all of the required expenditures was prepared.

Approval of Plan

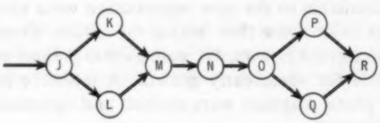
The entire plan was prepared in written form and submitted to management. In addition, a flip chart presentation was designed for a backup. The flip charts were later used in presentations to engineering personnel. The participation of the key managers was beneficial in obtaining their support. With the predetermined objectives and overall concepts achieved, almost immediate management approval was obtained.

Adjustments to Plan

Only one minor change was made by management to the plan as submitted. This change was made, and the implementation program was started ahead of schedule.

Implementing Plan

The activities determined during the development of the implementation plan are outlined in Fig. 2. Following are observations made to highlight actual experiences encountered in the implementation.



Implementation Activities

J–adjustments to plan (from Fig. 1)
K–announcement of new organization
L–announcement of key staff appointments
M–familiarization sessions
N–prereorganization changes
O–change over to new organization
P–relocate personnel
Q–post reorganization changes
R–post reorganization audit

FIG. 2.—Logic Diagram for Implementing Organization Change

Announcement of Reorganization and Key Appointments

The announcement of the new organization and the official announcement of the previously-selected department managers were made by the vice president of engineering.

Simultaneously, each of the new department managers made announcements of their new organizations, new section managers, and other key staffing assignments.

Familiarization Sessions

The decision was made to hold the presentations explaining the changes in a series of group meetings corresponding to the new sections of the organization. In each section the vice president of engineering and the department manager started off the meeting by introducing the new section manager. From that point on, the section manager ran the meeting. This role reinforced his new position. The planning team members reviewed the character of the new engineering organization, the reasons for the change, how the new organization would function, and finally, the project manager went into detail about the implementation plans. These sessions ran for about an hour. Thirty-one of them were held to include personnel from both within the engineering organization and from the outside departments. "Make-up" sessions were held for those persons necessarily absent when normally scheduled. Approximately one-half of the session was spent in a question and answer period.

Without a doubt, the care with which these presentations were made was a very major factor in the acceptance given to the new organization by engineering personnel.

Pre-Organization Changes

Some changes were necessary prior to effecting the reorganization in order to assure a smooth changeover. In an engineering organization these might include: (1) Preparation of transfer papers for each person to a new organization; (2) revision to the accounting systems where time keeping is input based on organizational units; (3) revisions to all computer programs making use of code numbers for organizational units; (4) modification/correction of all project man-hour budgets, forecasts, and man-hours expended to date kept by organizational units; and (5) advising each client of the changes and assured that these these changes will not affect his project adversely.

Changeover to New Organization

The actual changeover to the new organization must not be done prematurely. Detailed checks must be made to assure that each of the preceding activities have been concluded. The change should be made at the earliest possible opportunity to reduce confusion. The organizational changes should be made before the physical relocations start.

Relocation of Personnel

The detail involved in this activity is more demanding than almost any other area. In the particular instance being described, over 95% of the 600 people were relocated. This particular activity occupies much of the time of the implementation project manager. He is assisted by design personnel to produce the drawings for building modifications and for furniture layouts. He consults with affected section managers frequently to minimize problems to operations. Personnel on task forces provided the more simple problem; these changes were generally minimal.

The strategy generally followed was to establish an open area that would correspond to requirements for an entire section. The necessary building modifications were scheduled and made. Personnel were generally moved after working hours to minimize disruption. An attempt was made to eliminate temporary relocations, but this was not entirely achievable.

Essential Post-Reorganization Changes

There are a myriad of changes which are required to preserve good order. These include development of new position descriptions, operational procedures, standards of performance, engineering instructions, and the procedural writings. The department or sections involved should prepare these, but the requirements were identified and coordinated by the project manager.

Post-Reorganization Audit

During the period of reorganization, it is necessary to be particularly responsive and sensitive to small problems that surface. It is impossible to predict all of these and to provide for them in the plan.

There will be some instances of incompatibility despite all precautions. These must be resolved in a positive manner. Some slight changes can be made where they do not affect the basic thinking or where new considerations are brought to light.

It is especially important for the planning team members to seek out the opinions of others affected by the reorganization, and to attempt to head off unnecessary problems that might jeopardize the success of the program.

Conclusions

The fundamentals expressed in this paper are generally applicable to organizational changes of a substantial nature. They point out the need for a great deal of planning, both for the new structure and for the implementation of the plan.

Organizational change can mean a great deal to the effectiveness of the operation if it is carefully done. The planning of the program can be very rewarding, especially if a participative approach is employed.

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Individual Development in Matrix Organization[a]

By H. Cecil Allen,[1] M. ASCE

Introduction

If a consulting firm is to expand and maintain a position of leadership in the engineering community, it must recruit quality engineers, develop them and, most importantly, retain them. This paper will discuss the development of graduate engineers in an engineering firm with a matrix organization.

The system for individual development is designed to incorporate the work performed for clients with the personal development goals set by each individual. The system must operate within the framework of the firm's workload and overall goals. The objectives of the development program are to: (1) Enhance the individual's professional development; (2) ensure that the firm maintains a position of leadership in its chosen fields of engineering by utilizing innovative and creative engineering while minimizing project cost; and (3) reward all individuals commensurate with their contributions.

This paper will consider the effects of the organizational structure on the individual's development. It also discusses both the history of the firm and the history of the organizational structures used. The development program discussed herein is directed toward the engineers during their first four years of practice. Although the development of engineers beyond this experience level is not specifically discussed, the same general principles are applicable.

Some of the terms used in this paper are specific and would apply only to Turner Collie & Braden Inc. More general definitions of these terms are:

1. Graduate engineer.—An engineering graduate who has not attained professional registration.
2. Technical chief.—Discipline supervisor or discipline manager who is assigned responsibility for quality assurance and personnel for a specific technical area of the firm's practice.

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Note.—Discussion open until December 1, 1981. To extend the closing date one month, a written request must be filed with the Manager of Technical and Professional Publications, ASCE. Manuscript was submitted for review for possible publication on December 19, 1980. This paper is part of Issues in Engineering—Journal of Professional Activities, Proceedings of the American Society of Civil Engineers, ©ASCE, Vol. 107, No. EI3, July, 1981. ISSN 0191-3271/81/0003-0175/$01.00.

3. Project director.—A team manager or functional supervisor who has responsibility for all work and personnel assigned to a project unit.

4. Project Unit.—A team organized to perform work in a certain area of the firm's practice.

Background

History of Firm.—Turner Collie & Braden Inc., headquartered in Houston, began with a staff of six people in 1946. The firm's initial practice was based

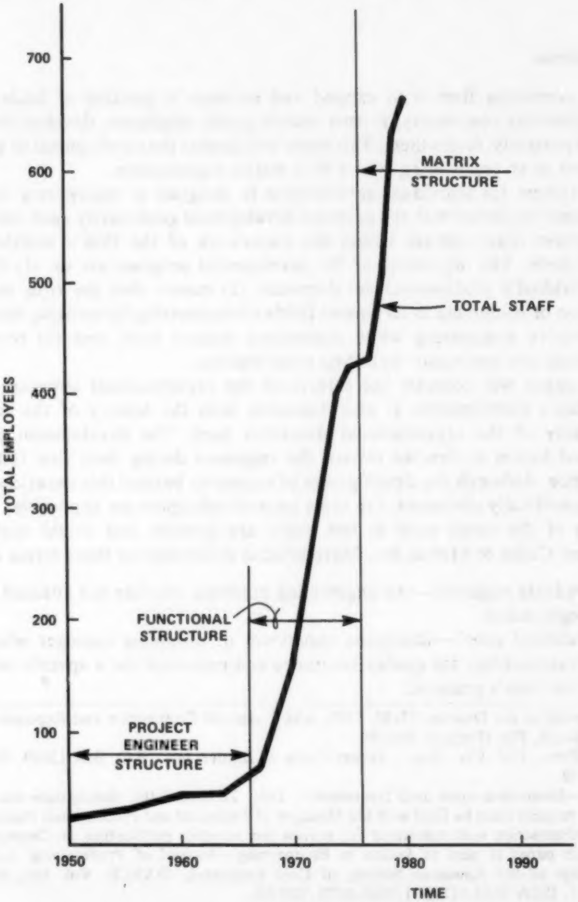

FIG. 1.—Growth and Organization Type Versus Time

on providing civil and public works planning and design services to municipalities.

Today, the firm offers diversified engineering services throughout the southwestern United States and in several foreign countries. The total staff of approximately 700 includes more than 200 graduate engineers, half of whom are registered in their respective fields of specialization. Fig. 1 shows the growth of the firm and the various types of organizational structures used in the past 35 yr.

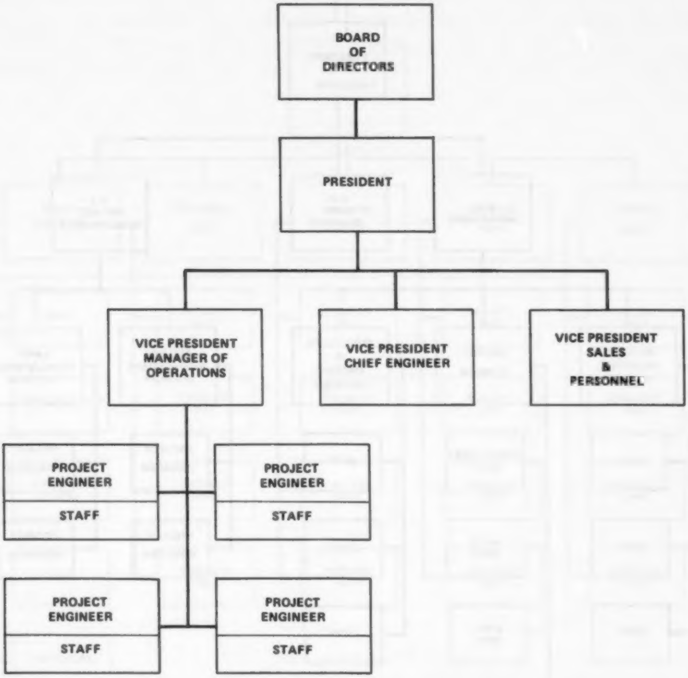

FIG. 2.—Project Engineer Organization

History of Firm's Organizational Types.—The first type of organization the firm used was a project engineer structure. Fig. 2 shows this organizational type.

The principal officers shown had separate functions: (1) Sales and personnel was responsible for recruitment and business development; (2) chief engineer, quality assurance; and (3) manager of operations, assignment of work and personnel. Under this organizational structure the individual had an opportunity to work closely with a project engineer on all aspects of a project. There was not a formal program to move engineers in order to diversify their experience. This structure developed individuals who were strong in all aspects of a particular

area of work. This development program fit the firm's practice at that time.

The second type of organization used was a functional structure which was implemented in the middle 1960s (see Fig. 3).

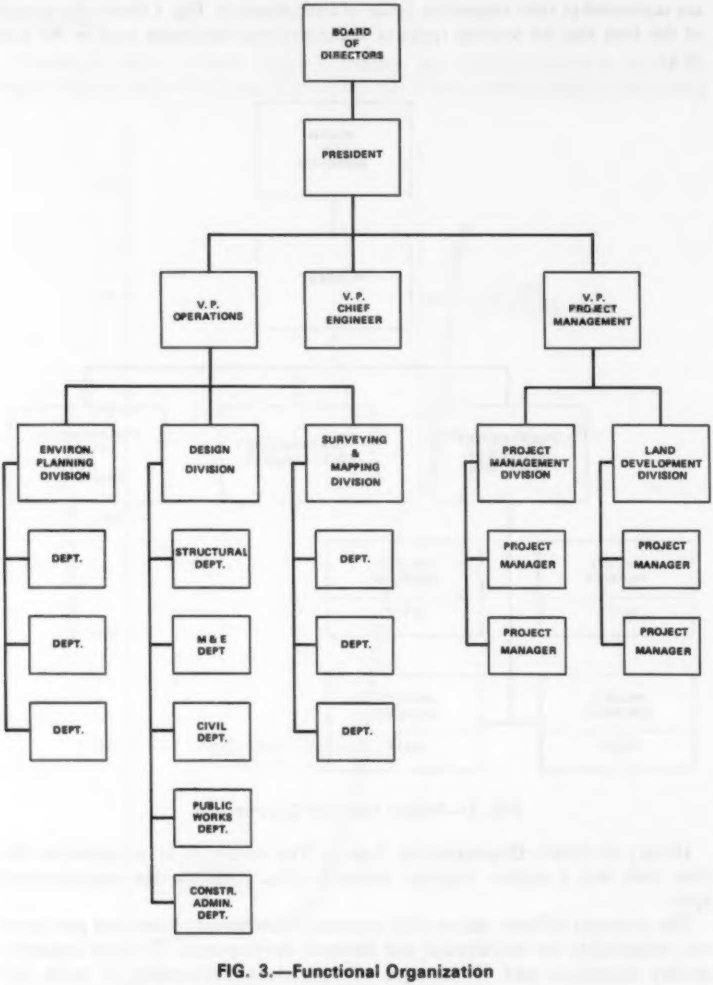

FIG. 3.—Functional Organization

The three officers shown had the same responsibilities as in the previous structure, except that the officer responsible for recruitment also was responsible for assignment of work and designation of project managers. In this organizational

structure, the individuals worked in a specialized functional area and worked only on the parts of the job that related to their functional area. This type of organization did not provide an effective system for moving the individual

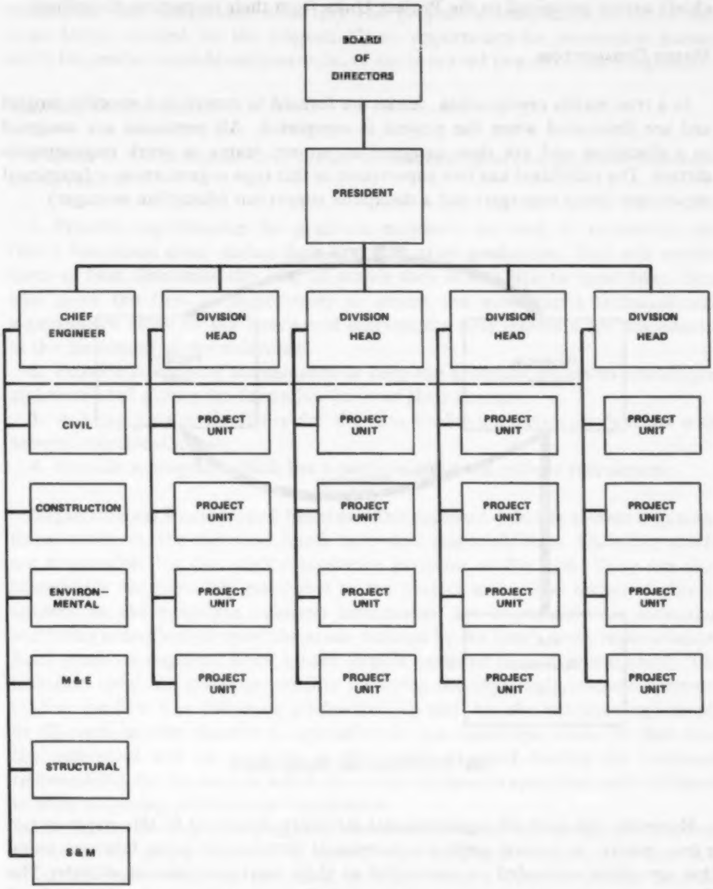

FIG. 4.—Matrix Organization

through the firm's various functional areas of practice. The individual tended to become specialized in either a technical area or a management area.

The third type of organization, which the firm currently uses, is a matrix structure (Fig. 4). Reporting to the president of the firm are a chief engineer and several division heads. Under the chief engineer are technical chiefs for

each of the technical descriptions. Reporting to the division heads are project units or teams, each managed by a project director. A project unit has the responsibility for handling all aspects of a project. Each project unit is staffed with sufficient personnel to perform its work in a timely manner. The technical chiefs assign personnel to the Project Units from their respective disciplines.

Matrix Organization

In a true matrix organization, teams are formed to complete a specific project and are disbanded when the project is completed. All personnel are assigned to a discipline and are then assigned to project teams as work requirements dictate. The individual has two supervisors in this type organization: a functional supervisor (team manager) and a discipline supervisor (discipline manager).

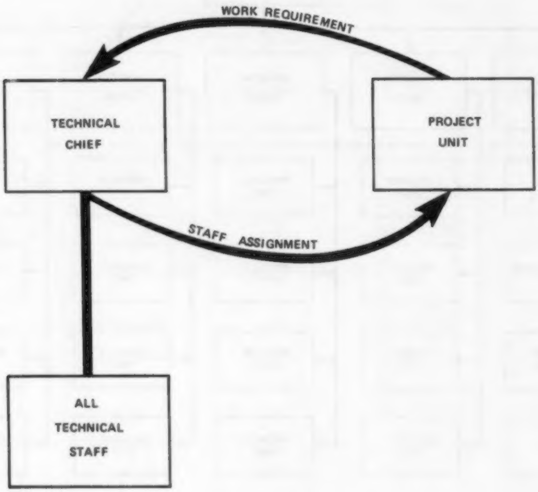

FIG. 5.—Personnel Assignment

However, the type of organizational structure discussed in this paper is not a true matrix, as project units are permanent fixtures (on-going business units) that are either expanded or contracted as their work assignments dictate. The firm assigns projects to a project unit in which the project director has a specialized expertise (technically or managerially) and assign the necessary discipline personnel at the times needed to accomplish the assignment. Like the true matrix structure, the individual has two supervisors, a project director (functional or operational supervisor) and the technical chief (discipline supervisor). In this organization, generally all technical personnel are assigned to a technical chief, based on the functional area of practice in which the individual is working.

An exception is graduate engineers, who for their first four years after

graduation remain assigned to a specified Technical Chief regardless of their functional work assignment (to be discussed further in the section "Individual Development"). Based on the needs of the project units, the engineers are assigned to project units for their functional assignment (Fig. 5). The individual remains in this assignment until: (1) The project is completed or he or she is no longer needed for the project; (2) an opportunity for promotion exists; or (3) for professional development, he or she is moved to a different assignment.

Individual Development

Objectives.—The objectives of the development program for graduate engineers are as follows:

1. Provide opportunities for graduate engineers to work in several of the firm's functional areas during their first 4 yr after graduation. This will enable them to best determine the area in which they would like to specialize. This also gives the firm an opportunity to assess the individual's technical and management skills so the firm's and individual's best interests are considered in the placement of the individual.
2. Provide interesting assignments to keep the graduate engineers challenged and motivated during the formative years of their careers.
3. Achieve greater flexibility for the firm by having engineers familiar with several functional areas.
4. Provide a program which has a positive effect on college recruitment.

Organizational Structure and Individual Development.—In the current organizational structure, the technical chiefs have dual responsibilities. Technical chiefs are responsible for the quality assurance program of the firm. They are also responsible for providing personnel to the project units. The technical chiefs, assisted by the employee relations department, are responsible for recruiting and hiring individuals to meet the needs dictated by the firm's work requirements. Each graduate engineer hired by the firm is assigned to a technical chief. The technical chief has the responsibility for being the engineer's inhouse sponsor: (1) For the first 4 yr following graduation; (2) until he/she becomes registered; or (3) until he/she decides to specialize in one functional area. At that time the individual will be assigned to the technical chief having the technical responsibility for the area in which he or she chooses to specialize or is assigned to after acquiring professional registration.

During the development program, the technical chief will assign the engineer to one of the project units. The time of this assignment varies. The technical chief will meet with the individual at least twice a year to discuss his/her goals, interests, and thoughts about the type of work he or she is currently doing. The technical chief and the individual will establish a tentative overall development program which will guide the engineer through the first 4 yr following graduation. The semi-annual meetings are intended to reevaluate the individual's goals within the firm's overall goals and work requirements.

Each planned step or move in the development program is agreed to by the graduate engineer and the technical chief. The move is discussed with the project directors involved and, with their concurrence, the timing of the move

is arranged. The moves to and from project units are timed to minimize disruption to operations of the project units. In some cases the graduate engineer assigned to a unit has the opportunity to work in several different functional areas within that unit. The engineer may be allowed to remain in the unit for as long as 2 yr. The firm encourages the engineer to move to different project units in order to experience several management styles and work types. He or she receives day-to-day work instructions from the unit director or the manager within the project unit.

Prior to each new assignment, the technical chief will discuss with the project director the engineer's goals. The project director and the chief will then assist the individual in meeting these goals. The project director will evaluate the engineer on the basis of his work assignments, and the technical chief will evaluate him on the basis of his technical progress. The engineer will be evaluated formally at the end of each assignment and also bi-annually, at midyear, and year-end.

With the technical chief, the engineer has a person with whom he or she can discuss technical as well as career development matters. This affords the individual engineer the opportunity to receive counsel from someone other than the day-to-day supervisor. It is anticipated that the graduate engineer will have assignments within the firm that will result in the development of skills in a broad range of engineering disciplines as well as in engineering management. The accomplishments and potential that the individual displays in a variety of assignments will serve as a basis for promotions and salary increases and will provide development of a well-rounded background in preparation for advancement within the firm.

The technical chief to whom a graduate engineer is assigned has the following responsibilities:

1. Explain the development program and determine the engineer's interests.
2. Assign the engineer to a project unit, based upon that unit's needs and the individual's interests.
3. Monitor the engineer's progress and determine when he/she should be rotated to a new assignment.
4. Coordinate transfers to other project units.
5. Keep in touch with the engineer and determine what his/her problems may be and provide appropriate guidance.
6. Participate in the evaluation of the engineer's technical competence.

A project director to whom a graduate engineer is assigned has the following responsibilities:

1. Provide the engineer with an interesting and challenging assignment and the necessary training and guidance.
2. Clearly inform the engineer what is expected and provide frequent feedback on the individual's progress.
3. Complete a formal evaluation at the conclusion of the assignment, and other designated times, and discuss it with the graduate engineer.
4. Communicate any problem or potential problem concerning the engineer to the appropriate chief of the technical department.

The employee relations Department maintains records of assignments and evaluations and assists in any other areas as needed.

Implementation.—Implementation of the development program requires close coordination by the technical chiefs, project directors, and the employee relations department. The coordination must be effectively handled since 20%–25% of the firm's engineers are in the development program, and mismanagement of this function could easily affect the firm's overall efficiency.

After the graduate engineer is brought into the firm, he is assigned to a project unit and technical chief based on the firm's work load and the individual's interests. At the first formal meeting between the graduate engineer and the technical chief (either midyear or year-end) the initial development program is agreed to. This initial development program will have an anticipated first choice and several alternative assignments outlined. A tentative date for transfer is agreed to at that time. All personnel transfers in accordance with the development program are made at midyear or year-end and correspond to the formal meetings with the technical chief. However, some moves of individuals may take place at times other than these two times, if dictated by the firm's work requirements.

The information resulting from meetings with all the individuals in the development program is turned over to the employee relations department and all planned moves are recorded. The recorded information provides the basis for movement of individuals within the firm and actually makes up the master plan of the development program. All personnel transfers are coordinated with the project directors in order to minimize the effect on the firm's work load.

The development program must be continually reassessed based on the firm's workload, new areas of practice, and changes in an individual's interests and goals. The program is continually updated as long as the individual remains in the program.

Conclusions

A matrix organization provides an effective vehicle for an individual to develop technical and managerial skills on a variety of assignments.

In this organization, the discipline manager has responsibility for quality assurance and personnel assignment. The most effective quality assurance program is one that uses highly skilled professionals who understand the firm's technical requirements and can effectively apply these requirements to the firm's work. The discipline managers in the matrix organization have a responsibility to develop these skilled professionals.

The team manager has an obligation to ensure that the engineers assigned to the team are used effectively and receive the necessary guidance to complete their assignments. The manager also has a responsibility to provide high quality engineering service to the firm's clients in a timely manner at a reasonable cost and at a profit to the firm. The best method for providing this service is to have highly skilled professionals available for assignment to the projects. This organizational structure provides extensive on-the-job training in a variety of technical areas. Both the discipline manager and the team manager are committed, through their responsibilities and work goals, to jointly develop these skilled professionals.

This approach helps develop engineers who are exposed to several different areas of the firm's practice and aids in evaluation and effective placement of these individuals both from the standpoint of the individual and the firm.

The positive effects of the matrix organization seem to outweigh the inferred negative aspects of the individual having two supervisors. Another possible negative point of this organization is that individuals moving from team to team do not have a fixed structure within which to plan their career. However, the channels of communications open to the individual (especially in the area of career planning) should overcome this point for most individuals.

In conclusion, the matrix organization provides a structure in which engineers can develop their professional skills, outstanding engineers can be easily recognized and rewarded, and all engineers can be provided with a variety of challenging and meaningful work.

Engineering Ethics: A University Course

By Paul C. Hassler[1]

Introduction

Ethics and ethical behavior have been talked about in engineering schools for many years. Ethics courses are not new to engineering educators. Few practicing engineers today have ever been exposed to a formal course in ethics, either taught by the Philosophy department or the Engineering department. Most engineering societies have ethics committees at the different levels in their structures. Too often these committees seem to be doing very little work. The writer can remember business sessions in which the report of the ethics committee was called for. Seldom was there any response and someone usually remarked to the effect that "no report was a good report." This supposes that there were no ethical violations. What it might mean is that no ethical violators have been charged.

Course Objectives

The writer feels it would be very difficult to include ethics in any sort of a voluntary continuing education program for engineers already in practice. It would be better to introduce a course at the undergraduate level as an elective and to work toward making it compulsory for an undergraduate degree in engineering. The students could be exposed to actual situations and their application to existing codes of ethics. The outside engineers brought in as visiting lecturers would talk of their own experiences and bring practice into the classroom. With this objective, a senior 3-h elective course proposal was started through the usual academic route for new courses. It must be said that it encountered less than usual opposition to a new course. It may also be noted that four months after the end of the initial offering of the course, the Philosophy department countered with its own new offering, which was entitled "Ethics and the Professional Person." Its degree of success remains to be seen.

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In the early years of practice, young engineers will probably encounter one or both of the following situations: (1) Indications from an event that has taken place in which there is a possible violation of the code of ethics; or (2) a situation wherein there is a chance of an ethics violation if a certain proposed course is followed.

Faculty members at the writer's institution had usually experienced such situations or had sat on review committees where such cases were heard. They were in universal agreement as to the desirability of such a course. They also felt that if offered, it should be limited to seniors from all engineering disciplines as much as possible.

Organization

The writer sought all possible information as to how other colleges had handled such courses and the methods used to conduct them. After considerable study, it was decided that a "case method" approach would be best. This is similar to methods used in law schools. For many years, the National Society of Professional Engineers (NSPE) has carried summaries of ethics cases in their publications. These have also been available in bound form for purchase by members. Some of these cases were selected to provide a backlog of case facts. Each case furnished the essential facts. Each case was reworked, giving it a number, title, date, and posing a final question for the students to resolve.

Preparations started about a year in advance. The cases were prepared for duplication and were filed according to the section of the code and subject. A cross file was established. Letters were written to many local engineers inviting them to participate. All who agreed to help were utilized.

Procedures

On the first day of class, copies of the NSPE and the ASCE codes of ethics were passed out. Copies of the laws governing professional registration in Texas were also distributed. This was done primarily for the code of responsibility and canons therein, but the attention of the students was called to the rules governing registration in the state. The NSPE code was named as the final document to be used as a reference for all cases. A "hard" copy for each student was produced by laminating copies in plastic. The balance of the material served to provide background resources. Nonengineering organizations provided additional reference material. The four-way test, published by Rotary International, is an example of the application of ethics to everyday living.

Some decisions had to await registration and a final count of the number of enrollees. The total number broke down nicely into Teams A, B, and C. These were designated, in order, as the Team of the Day. At the second meeting of the class, two cases were distributed in their entirety to the students. They could then see the facts of the case, the decisions rendered by an actual review board, and the discussion and reasoning behind the decision.

The course was a 3-h affair. This meant that it met three times a week for 50 min a day, for a 15-week semester. Two cases were selected by the instructor and assigned ahead of time for each class meeting. Each member of the class had to study these cases and work out their own solutions. The

members of the Team of the Day for that day had to make a much more detailed study and be prepared to present a more rigorous solution. Impressed upon all students was the fact that a simple yes or no answer was not enough. Their decisions had to refer to particular section(s) of the code and the reasoning behind the decision had to be developed. The study of these complete cases early in the term aided in showing students how much detail was expected.

At the start of the case, one or two students not on the Team of the Day were called upon. They gave short opinions of the case and stated the section of the code they felt was involved. A member of the Team of the Day became the official "presenter" for that case. He gave an in-depth study of the case and his conclusions. It was during this period that questions and discussions were held. The presenter was expected to handle the discussion and to keep the class on the subject. Usually, he concluded by taking a vote. This meant that about 22 min were the most that could be devoted to any case. Some cases were disposed of in less time. In some, the presenter had to close a lively discussion due to time limits. The attempt was to cover three cases per period, but this proved to be too many.

The instructor kept records of who participated in each session. These were balanced as much as possible so that in the long run each student had about the same number of opportunities to participate before the class.

Outside Speakers

Case studies occupied only two periods per week. The third period was used to bring in outside engineers as guest speakers. All interested faculty were utilized. Most of the speakers were practicing engineers in the city. It had been impressed on these engineers that the class was interested in hearing of their own personal experiences in ethical situations. This was most successful. It was possible to involve both recent graduates and engineers of long practice and experience, as well as two female engineers. It was stressed to all visitors that this was not a matter of saying to the students, "Well, it says in the code not to do this, so don't do it." The writer feels that there is no better way to tie practice to the classroom than to utilize outside engineers involved in industry, consulting, and government. However, the individual must be selected with care. Many are prone to spend the period telling how they got theirs the hard way, telling off color stories, or bragging of their own accomplishments—a situation not entirely unknown among faculty members.

Outside Interviews

Some local engineers wished to participate but did not want to appear before the class. Their experiences were used by an interviewing project. A letter explaining the course and offering an invitation went to the engineers. A second letter followed giving the name of the student who would be contacting them for an interview.

The instructions to the students were to call and make an appointment. They were then to take notes of the situations the engineer talked about and prepare the facts of the case in the format used in class. Each was to end with a question. The student was then told to select at least two, but not more than

three, of the most interesting cases which had come from his interviews. Each student interviewed two local engineers. The interviewer presented these cases near the end of the term. The class then discussed them, but no votes were taken. Each student had to turn in a written statement and solution to each case he prepared from his interviews. For class presentations, identifications were masked and false names were used. The student inserted his own name as the party suspected of the ethical violation.

It was originally planned to include some nonengineers as speakers and interviewees. This might have included some politicians, city officials, editors, businessmen etc., but time prevented their use in this first offering.

Written Assignments

During four or five class meetings, a written assignment was announced when class started. This was in lieu of the usual oral presentations. The case involved was one from the daily assignment, but students had to write without benefit of any previous notes on the case. These written assignments were checked by the instructor for spelling and grammar. They were returned to students for grading in class, although no student graded his own or knew whose he was grading. Some remarks noted by student graders were quite strong. These were again checked by the instructor and returned to the authors. Thus, everyone had a chance to see what his fellow students thought of his work. The grader placed a grade on the paper and these were recorded and used in the determination of the final grade for the course.

About 2 yr prior to this offering, one of the departments in the College of Engineering had developed a code of ethics of practice for its faculty and students. This was due largely to the person who was then departmental chairman. Copies of this code were passed out to the class and students were asked to supply a written critique of the document, especially toward possible modification and adoption by the Civil Engineering department. About two weeks were allotted to this homework study, and the faculty was surprised at some of the comments.

Testing and Grading

If a letter grade must be assigned, then some sort of testing must occur. Engineering faculty are generally not accustomed to grading essay-type tests, being much more familiar with problem-type tests. However, that problem is not as difficult as it might seem. A midterm test was given by passing out a new case in class and having each student write his analysis and decision, with the code as his own reference. A similar plan was used for the final exam. These grades, plus the written assignments, plus a grade on participation provided the basis for the final letter grade.

Flexibility

No course can be completely rigid. Some changes must be expected during and after the first offering, and periodic reviews held later on. Cases with many parties involved and designated as Engineer A, B, C, etc., proved very

confusing and difficult to straighten out in the time available. The use of names made no difference. It was apparent that about three parties were the most that could be involved in any one case.

Cases involving labor disputes, campus situations, illegal contributions, and possible felonies proved to be the most interesting. Others were rather boring to the students. Very few produced a unanimous decision one way or the other. Most were split votes. Some students tended to confuse an ethical board of review with a jury—where a unanimous decision was expected. In order to avoid influencing the thinking of the class, no decisions published by the board were given to the class. At times, the students came up with aspects which the board may have overlooked. The instructor was surprised at the rather conservative attitude of the students as contrasted to the more liberal attitudes of a decade or so ago.

About midway through the course, the ASCE videotape of the mock professional conduct hearing was shown over closed circuit television. Part I provided some lively comments and discussion prior to the showing of Part II. The possibility of the class conducting its own mock professional conduct hearing was suggested, but sparked no real interest.

Evaluations

Student evaluations of courses and faculty have been a part of the program at the writer's institution for many years. The form used provides space for answers to specific questions, as well as a place for general comments. The instructor normally receives a typed summary of the comments plus a number representing the responses to specific questions. The evaluation of this course was high.

A separate evaluation was conducted wherein the student was asked only one question, "What changes do you think should be made in this course for the next offering?" The most common answers were as follows (not in order): (1) More writing should be included; (2) students wanted to hear the official outcomes of some of the cases which had been published by the NSPE review boards; (3) a few students tended to monopolize the discussions—a fault of the presenter for the case; (4) students wanted to be required to study individual code sections and to be tested thereon; (5) more preliminary material and discussions were needed on ethics, legalities, etc., before the case study was started; (6) more outside speakers were requested; and (7) mock trials were suggested.

Most students felt that the greatest benefits to them were an understanding of how ethics and ethical decisions might be involved in their chosen field of work, plus a better understanding of codes of ethics and what societies were doing in the matter. Only one had taken a formal course in ethics in the Philosophy department.

Future Plans

As a result of the first offering and the comments, definite changes will be made in the future: (1) Fewer cases will be used and these will be simpler ones; (2) fewer interviews will be held and more speakers will be brought in

from outside; (3) some nonengineers will be invited to visit the class; (4) the number of written case studies will be increased; (5) some exams will include four or five possible steps that might be taken to resolve the case, and the student will have to choose and justify his choice; (6) preliminary periods will be devoted to general discussions of ethics, legalities, and individual sections of the code; (7) a careful distinction between what is ethical and what is legal must be made, because students confused them; (8) the mock conduct hearing tape will be played earlier; and (9) a mock professional conduct hearing will be conducted and may be filmed by the Instructional Technology Center at the university.

While the preceding changes may seem like many, the writer does not feel that the course was a loss—far from it. It merely represents adjustments that must be made after the first time at anything. The writer also feels that the first step has been taken at his institution to activate interest in ethics and ethical decisions as they relate to engineering practice and that interest in the course will spread.

Recommendations

Junior and senior years at most universities allow for the inclusion of elective courses. These are often designated by the faculty as technical and nontechnical electives. Technical electives are often specified as being from engineering, mathematics, science, and sometimes business courses. Courses in engineering ethics, engineering law, and engineering economy can meet the technical elective definition even though they carry titles such as ethics, law, or economics. These are taught in the colleges of engineering by engineering faculty, primarily for engineering students. Some engineers feel that they are important enough to be part of the required curriculum for all engineering undergraduates. At the writer's institution, only the engineering economy course is so designated at the present time.

The writer feels that it would be useless to consider a voluntary course in ethics for practicing engineers due to a lack of interest and time. However, it might be a part of a package for updating or continuing education for engineers if this ever becomes mandatory.

The following recommendations are made to anyone considering a course in ethics for undergraduates.

1. Keep the class small enough so each student can participate at least once a week. Three or four students made a desirable size for a team.
2. Select the cases carefully. Vary the subjects to cover different sections of the code. Don't try to cover too many cases per class. Make notes of the student reactions to each case as a guide for reuse.
3. Limit the number of parties in any one case to three. Any more than three become too confusing.
4. Rewrite the case, making it as simple as possible. Pose a definite question at the end. Give each case a number and a title for reference.
5. Use at least one speaker from outside each week. Select them with care and impress upon them just what is expected. Use nonengineers and public figures, as well as engineers.

6. Provide as much supplementary material as possible. Have back issues of such publications as *Engineering Issues* available. No text is needed, but a list of supplementary reading material, and where it can be found, is necessary.

7. Explain procedures clearly at the beginning of the term. If changes become necessary, discuss the reasons for making them with the class. If possible, give the class a choice and let them vote.

8. Don't neglect writing assignments, both in class and as homework. Don't be afraid to insist on good grammar, spelling, etc.

9. Publicize the course widely in all departments and among faculty advisors. Don't limit enrollments to engineers.

10. Play the professional conduct tape, and encourage the idea of students conducting their own mock trial.

11. Use a definite evaluation procedure toward the end of the class term. The writer has yet to find a better evaluation procedure than to request answers to three questions: (1) List the good points of this course; (2) list the bad points of this course; and (3) what changes should be made next year?

12. Keep an on-going file of information that might be used in the course. Condense it and pass out copies. Include any published accounts of actual professional conduct hearings by the different societies as reported in their news magazines.

13. Assign cases one week in advance with a definite data for their presentation in class. Set definite turn-in dates for any written homework.

14. Experiences in grading essay-type tests will make the job easier. List the main points a student should be expected to note in his review. His grade then can be weighed according to how well he covers these points. It is not difficult to discover the student who is merely "bulling" around without really saying anything.

15. Rework your case file constantly. Eliminate those that are unsuitable. The writer has found it helpful to classify cases as outstanding, average, and poor, according to their suitability for class use. Keep adding new cases to the file.

16. As the instructor in the course, keep quiet in class. When the cases are being presented, let the student presenter handle it. Introduce your outside speakers and then take a seat in the classroom. Answer questions directed to you by students if possible, or tell them where they can probably find the answer. A tactful suggestion such as "How about this route?" or "Have you considered all alternatives?" may direct their thinking to an unexplored angle or route.

[illegible]

Engineering: Answers for the 1980s[a]

By Dan H. Pletta,[1] Hon. M. ASCE

Introduction

The title of this paper intimates that the engineering profession will respond, as it always has, to fulfill societal demands for better living standards in the 1980s, hopefully with equal "apparent" success. I use the term "apparent" because there always have been critics who questioned "progress" if it wasted nonrenewable resources with planned obsolescence, or which endangered the environment. These critics have gained enough political support in the United States during the past several decades to foster most of the governmental regulatory agencies like the Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA), and Consumer Product Safety Commission (CPSC) that now total over 100. Can we conclude that many of these bureaucracies were part of the engineering answers of the 1970s?

All students are painfully aware that, for them, answers are always preceded by questions, and questions by courses. Research workers are delightfully surprised occasionally to uncover answers to questions they never asked. Engineers soon learn that proper solutions emerge only after the technical problems are formulated by asking the right questions in the proper sentence.

If, then, engineering answers for the 1980s are to be discussed, it seems appropriate to first ask a few pertinent questions. Before these can be asked intelligently, however, we should have at least a cursory understanding of the societal environment in which engineers will be expected to practice. Accordingly, a brief discussion of those conditions which will affect them as professionals will be covered first. The discussion and the questions which follow will cover the following general topics: (1) Obligations, leadership, and creativity; (2) economics, freedom, and regulation; and (3) education, ethics, and qualifications—all as they relate to professional practice.

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Answers will be alluded to in the discussions, but brief statements—pro and con—will follow each question. Suggested goals and challenges will be reserved for the conclusions.

Societal Environment

Today's societal environment is but the interface between that of the future and that of the past, which served as its foundation. That environment was affected by the economical, political, and ethical systems which governed its behavior. These systems affected, and were affected by, the way engineers were educated, became qualified, and did practice.

Only two centuries have elapsed since the industrial revolution began. During those 200 yr the craftsmen, technicians, engineers, scientists, and managers who comprise the technological spectrum produced as much material wealth as had been amassed since the dawn of history! They accomplished that incredible feat by harnessing energy and by exploiting innovation. Most of that progress occurred in the western world where political freedom and free market capitalism flourished. There was little governmental regulation of production. The monetary systems then were usually founded on sound money which, as defined by Aristotle, was a guarantee of present value in the future.

Today's floating—or sinking currencies—are not! Much of the world is now plagued by an inflation of fiat money which influences long range planning, bloats bureaucracies (governmental, industrial, and educational alike), and reduces productivity. Politicians favor inflation for it helps them get reelected—and so they prolong it. Throughout history, all inflations of the money supply collapsed except when they were related to increased production.

During the next 25 yr the world's population is expected to inflate by 55%. Whether the world's housing and supporting public infrastructure can be expanded at that pace, as resources dwindle and inflation continues, will pose a gigantic challenge, particularly for engineers. Their success will be accelerated by free market economics but retarded by governmental regulatory constraints. Furthermore, governmental funding for such national projects as the MX missile complex (5) or alternate energy developments will divert resources from societal necessities. The practicality of such projects involves political trade-offs. Sometimes their completion produces economic benefits, as happened with the Panama Canal, Hoover Dam, and space exploration. The interstate highway system benefited the trucking industry but bankrupted many railroads and delayed construction of urban subways. Other national projects like the French Maginot Line fortifications and the Egyptian pyramids proved useless except as memorials.

Engineers and scientists are generally better able than laymen to advise legislators on the practicality of such projects. Their recommendations will seldom be unanimous, and may consider alternate systems. Results of their studies should be presented at public hearings; acceptance of them may prevent costly blunders. An agency to advise Congress on such issues was initiated in the 1950s when what is now the Office of Technology Assessment was created (10). Some of its recommendations that involved the long term commitments needed for major projects did not fare too well. Politicians prefer to support short term solutions whose rapid completion enhances their bids for reelection.

The need for engineering leadership in the societal sector should be evident from the foregoing discussion. Such leadership is crucial if nonrenewable resources are not to be wasted on impractical public missions, or on industrial products designed for obsolescence merely to ensure a greater monetary profit. If we assume that the primary purpose of engineering is: (1) To use the materials and forces of nature for man's comfort and benefit; and (2) to protect the public's safety, health, and welfare as a paramount responsibility (this obligation is found in the codes of ethics of most major engineering technical and professional societies); then we classify engineering practice as professional. Such status implies a willingness on the part of the practitioner to subscribe to the obligations just cited, and to discipline those of his peers who cannot or will not meet them. Society also expects a professional to adhere to an ethic at least similar to the one proposed by Wisely (12) whereby the practitioner will "pursue a learned art at all times within his competence and in the public interest—with integrity, honor and dignity."

Acceptance of such responsibility is an implied facet of leadership but there is little that a professional can accomplish without the support of his peers. He needs not only to support the technical societies that advance his art, but to unify them professionally for political effectiveness. Engineers have tried since 1829 to exercise leadership through a score of unity organizations. Almost all were federations of engineering societies rather than organizations of individuals. All have failed. One can hope that the latest effort—the American Association of Engineering Societies (AAES)—which was founded January 1, 1980 will succeed. There will be a crucial need for engineering leadership in the future to help in selecting suitable public missions, in bolstering our free enterprise system, in curtailing unneeded governmental regulation, and in expanding our professional freedom for more responsible practice.

The foregoing discussion has implied that the engineer is not free politically, economically, or scientifically. His constraints were described by the poet Housman (3) as "These foreign laws of God—and man." The engineer knows that he cannot flout nature's laws without suffering retribution. He seldom does: he understands them. They are simple, enduring, and few in number. But manmade laws and the regulations they authorize also affect his practice. The laws are so numerous and confusing that nine learned judges reverse their interpretation of them periodically as the societal environment changes with time.

The confusion arises frequently because the laws, which create the regulatory agencies in the *executive branch*, are badly written by Congressional aides in the *legislative branch*. Therefore, the regulations are hard for public servants to write and to apply, as well as difficult for the *judicial branch* to adjudicate.

These regulations vary geographically. For instance, automotive emission standards vary world-wide from zero to others some experts deem too stringent. Likewise, arguments persist over whether oil tankers entering certain harbors should be built with double, rather than single hulls, so as to minimize oil spills.

Economic systems also span a wide spectrum. Productive systems can be owned totally by governments (socialism) or by people (private enterprise). Today, all systems are mixed and include elements of welfarism and economic regulation as well. Governments influence the economy and technology by support and

regulation. The process is akin to driving a car with your foot on the accelerator and someone else's on the brake. Support includes funding for projects, purchases and research, and expansion of money and credit. Governments also endeavor to control the whole economy.

There are six agencies regulating banking and finance, six regulating trade competition, four regulating employment, five regulating energy and environment, and six regulating safety and health! Engineering practice is constrained by all 27 agencies. Every engineer should be aware of their existence but will have to be painfully familiar mainly with the last six and their countless pages of regulations.

One can wonder why so many regulatory agencies were spawned. Was it because business and the professions failed to regulate themselves, or to discipline those too indifferent to care? Did these agencies expand exponentially because bureaucrats were over zealous? Would it not have been easier and more productive to protect the public interest by holding all professionals-in-charge accountable to their peers?

Our over-regulated economic system now has 68% of American industrial executives worried about the ability of their corporate structures to survive the next 25 yr (2). They are countering with paid advertisements the anti-business, pro-union views, taught almost exclusively in schools. These ads state that only free market capitalism is totally democratic; all customers are franchised to vote in the world's markets with their own money.

Technology and economics permeate all political boundaries even though national tariffs and regulations restrain their effects. Technology and economics unite mankind into the one world which Wendell Wilkie endorsed in his unsuccessful 1940 presidential compaign (11). The removal of all economic controls might lead to the increased production and peaceful cooperation the world has been seeking. Perhaps, however, "the global economy has already been conquered by the cold logic of profits" as advocated by Rockefeller's Trilateral Commission in Bill Moyer's recent TV 20/20 program (4).

Technology must be controlled by responsible practitioners, or by regulatory agencies, or both whenever the public's safety, health, resources, or environment are endangered. There would be no need for these bureaucracies if acceptable professional standards, like the American Society of Mechanical Engineers (ASME) High Pressure Vessel Code, were available for all product designs. These develop, however, long after the first prototypes are produced and so are unavailable for innovative creations. The application of pertinent scientific principles could suffice in such cases if only knowledgeable professionals had the final authority to make the technical—as distinct from the economic—decisions.

When such responsibility is not permitted and the public's welfare is threatened, regulatory agencies are created. The standards they develop fill thousands of pages, are frequently irrelevant, and always costly to apply. The expense for their direct support, plus the burden they place on all businesses, has been estimated to be five times larger than net profits as based upon sales (6).

For instance, General Motors Research Laboratories sometimes divert half of their resources to meet these regulations. Dow Chemical Company, in 1976, estimated that only half of the compliance money could be justified for the safety of the workers, customers, and public. The rest was "beyond good scientific

manufacturing, business or personnel practices" (1). Steel companies would have had to spend $1,200,000 per steel worker to satisfy OSHA inspectors. They accomplished comparable employee protection for $42 per worker using ear plugs, monitoring equipment, and physical checkups.

No one needs to remind engineers that regulatory constraints reduce productivity by diverting resources and labor. Engineers are not as aware, however, that other governmental and corporate constraints also reduce productivity by constraining creativity. Patents, for instance, are frequently regarded as monopolies, rather than as property with a 17-yr life. The Department of Justice has frequently filed amicus cruiae briefs prejudicial to the inventor, instead of protecting his ownership in court without charge, as is the case in Germany (7).

Similarly, corporate policies required employed engineers to assign their patentable innovations to their employer when they are first engaged. No predetermined awards are specified by the corporations as they are in some foreign countries. Many companies now prefer to protect innovations as trade secrets because legal fees spent in defending patent infringement suits often exceed royalty payments.

Some foreign governments, notably Russia and England, reward inventors. One Russian engineer has been paid over $1,000,000 for his patents. England awarded Sir Whittle, inventor of the jet engine, £ 750,000 tax free! (7). Overall results of these United States constraints and foreign incentives from 1971–1978 have resulted in a decrease in patents granted annually to Americans from 56,000–44,000 while those granted to foreigners increased from 8,500–27,000 (9). During this same time interval the United States trade deficit has grown.

The trade deficit could be reversed by allowing the government to guarantee restricted loans to entrepreneurs for promising developments (9). Small industries according to Schumacher's book, *Small is Beautiful*, are more socially acceptable (8), and they are three times as efficient as large ones in earning profits on invested capital—but they lack capital. Yet they produce most of the significant inventions (7). Examples are lasers, computers, insulin, Xerox copiers, and Polaroid cameras. Exceptions are TV systems and the transistor.

Productivity could also be increased by imposing some governmental restraint on labor unions. One can only wonder why monopolies and contract violations are prohibited by government for business but not for labor unions. Labor unions sometimes restrain production particularly in the building trades where they prevent any interchange of incidental job functions between skilled laborers. Unions have benefited labor and have succeeded only because they can halt production by striking. But strikes are of little use to engineering staffs because production can continue for a while even if engineers stop working. Furthermore, many engineers aspire to management roles, and these are excluded legally from collective bargaining. Only on college faculties have unions been successful, unionizing engineering professors. There they are submerged in the whole faculty and prevented from constituting a separate bargaining unit for professionals, as is the case for medical and law school faculties or professionals in industry.

Although unions, in 1979, attracted 19% of industrial workers, 39% of public employees, and 25% of college faculty, they managed to attract only 4% of employed engineers for the reasons previously mentioned. These engineers might never have joined had their professional societies been able to do more than

they did, and to enhance employment conditions, economic rewards, and peer support through professional ombudsmen, especially when the engineers were endeavoring to protect public safety and to uphold ethical codes.

The foregoing discussion of the societal environment in which engineers must work should leave little doubt but that the host of conflicting issues make the world seem to be hopelessly complex. However, the same can be said about the natural environment. Yet the engineer has learned to adapt that to the comfort and convenience of his fellowman. He has accomplished that feat by applying the few scientific principles he needs. His success can be measured by the economic and social incentives provided by society for his service.

The future will demand more of the engineer if technological progress is to continue. He can continue to improve his service if incentives can be expanded, if controls can be removed, and if his professional objectives can be awakened and broadened. The questions which follow endeavor to cite the few critical social issues which should guide the engineering professional in adapting man's societal environment toward a more satisfying existence, just as the scientific principles guided his technical achievements. The brief answers which follow each question may generate the initial formulation of such social principles and serve as some "answers for the 1980s." Firstly:

Question 1.—Should engineers broaden their practice by participating in the development of technological missions, and by exercising societal leadership? Or should engineers serve the public only by improving living standards, increasing material wealth, and operating technological systems that society or industry, or both, approve of or specify?

Answer.—*Engineers* can and *must*, if they would practice as professionals whose "paramount responsibility is to protect the public's safety, health and welfare," *assume active leadership roles* which assist public bodies in the *formulation of appropriate* technical and societal *missions*.

Engineers are uniquely educated to formulate and to solve problems logically. Should they continue to remain as passive in the future as many of them have in the past, there is a grave danger that our fragile democratic environment will change, perhaps violently, into one far more dictatorial and collectivized.

Question 2.—Should engineers-in-charge assume public responsibility for the design, production, and operation of the systems products and processes which they supervise? Or should their practice be protected by the corporate legal structure or by governmental regulations, or both?

Answer—Simply stated, the questions might read, "Where should the buck stop?" For a physician it stops with him in the hospital; for an attorney, in the courtroom. All managers know that the most efficient and loyal organizations are those in which authority and responsibility are delegated as far down the hierarchy as possible to the professionals-in-charge.

Were that the case in engineering, there could be far less need for regulatory agencies like OSHA and EPA, for the public would know where to pinpoint responsibility. Confusion exists now as to whether he, his employer, or a governmental agency is at fault if some product or practice endangers the public.

One may argue that an engineer-in-charge will then have to be compensated more adequately. Perhaps so. It is more likely that he will use *designs as fool-safe and long lasting as possible*, but never acquiesce to corporate pressure to practice in a questionable manner. *He has seldom been so pressured, but such events have occurred* often enough to generate support for regulatory agencies, and to cost the public and the industries involved billions of dollars. If, for instance, engineers knew that they—not their employer—would be responsible for burying industrial wastes in land fills that might later be disturbed by government agencies so as to require evacuation of whole neighborhoods (13), they would explore alternate safer solutions.

As a matter of fact, these engineers could not then escape responsibility by merely warning their employer about the dangers of such unsafe practices in written reports. Today, they can appeal for help to professional society ombudsmen (ASCE, NSPE, IEE, ACS) if the public health may be endangered. Had such objective, confidential investigations been available previously, and had industries found safer solutions, temporary profits would not have degenerated into losses like fines, legal fees, or damages. Other cases than those involving waste disposal are described in books like *In the Name of Profit*, *Destination Disaster*, etc.

Perhaps the public's safety will be protected best and at least cost by *holding the engineer-in-charge professionally accountable, and the corporation financially responsible, with the role of the regulatory agency reduced to a minimum*. Unless this regulatory genie can be squeezed part way back into his bottle, the public may need to be protected from its protectors:

Question 3.—Should engineering professionals assume an active role as the public's advocate, or as the lobbyist's adversary, or both, whenever the "public safety, health, and welfare" is endangered? Or should engineering professionals maintain a passive role in the political arena?

Answer.—Engineers have been passive far too long! Laymen and most legislators cannot possibly know in advance how technological systems—or products—will affect their safety or resources as these are proposed or altered. Engineers do know—or should. If they would practice as professionals, they would feel compelled to advise the public about the pros and cons of technical issues.

The interstate highway system might be used as an illustration. Each year the trucking lobby tries to pressure legislatures to increase the allowable axle loadings and size and speed limits for tractor trailors. Most of their arguments make no engineering nor economic sense! Every engineer knows that structures cannot be loaded beyond design criteria without the possibility of initiating fatigue cracks due to repeated overloads. Pavements fail and bridges collapse when such fundamental principles are violated. (The suspension bridge over the Ohio River at Point Pleasant, Ohio collapsed in 1967 killing 46 people. *Legislators* raised the load limit to 20-ton trucks after it was designed and built for 15-ton trucks! Were they practicing engineering without being licensed?)

The cost to society due to failure of the engineering profession to intercede on the public's behalf has been staggering. Some feeble efforts have, of course, been made for such issues as energy and nuclear power. But the emotional

appeals of celebrities like Jane Fonda have been far more effective than the engineer's logic, mainly because the engineers played too passive a role:

Question 4.—What change in patent laws, corporate policies, or research support would enhance the engineer's obligation to innovate creatively?

Answer.—Patent laws might be changed requiring the Department of Justice to protect the inventor's patent in legal actions at no cost to him. Corporate policies might be altered advising prospective employees of the royalty rights they would be paid on their inventions *if* they are *patented and marketed*. Policies—or laws—should specify that the inventions will revert to the employee if the employer fails to apply for a patent, or fails to market one that is granted, within specified time limits. Otherwise, ownership of the patent could—and perhaps should—remain with the employer to whom the employee assigned it.

Question 5.—Should engineering professionals endorse only those economic systems which maximize production of essential goods and services? Or should they practice their art, indifferent to socio-economic constraints.

Answer.—Any engineer—or other citizen—who fails to support the *economic or political system* which guarantees him the greatest benefits and freedom does not deserve either. Eternal vigilance is the price he must pay.

Question 6.—Should engineering professionals be expected to always conserve the public's resources and environment in the performance of their professional duties? Or should they design for planned obsolescence whenever management estimates that will yield a greater monetary profit?

Answer.—Unfortunately, greed rules all economics and political systems. There must be trade-offs in them—and in engineering designs—if those systems are to survive. Engineers should endeavor to produce the most enduring products and systems that the current state of their art permits and at the least cost in energy—not money. That policy would require a modified economic system. However, trade-offs should never be allowed to degenerate into public rip-offs that waste resources or injure people.

If, for instance, autos were built, and then maintained, to last three times as long, laborers could work one-third as much and be paid three times as much in money. But society would save three times as much energy as is now needed to mine the ore, produce the materials, fabricate the car, and ship it to the buyer:

Question 7.—Should engineering professionals assume most of the responsibility "to protect the public's safety, health and welfare" under their profession's ethical codes? Or should governmental agencies assume most of that burden by legal restrictions?

Answer.—Unwillingness of engineering professionals to accept complete responsibility for the enforcement of their ethical codes or to adhere to the belief that such codes should be suggestive rather than mandatory has led to the continuing expansion of governmental agencies to regulate engineering practice. That trend increases productive costs, increases deficit spending, reduces available capital, increases litigation, and ultimately results in the loss of political freedom.

Ethical principles are not necessarily laws. Ethics is the law above the law and is essential for civilization. Thus, ethical enforcement should never be undertaken by government. Enforcement should be accepted by engineering societies—preferably a *unity* organization—in which *individual* membership is applied for voluntarily:

Question 8.—Does government influence over technology (through financial support, purchasing, regulation, expansion of money and credit, etc.) cause it to outpace social progress? Or does government regulation constrain social progress unduly?

Answer.—Unfortunately for society, the social scientists have far fewer principles or units with which to measure social phenomena than have their colleagues in the physical and life sciences to study natural phenomena. Thus, social progress is hard to measure. For instance, the question of whether an abundance of life's necessities reduces the will to work or increases crime is debatable. Government does influence technology, but it is not the only societal force contributing to what Alvin Toffler calls future shock. One thing is certain: civilizations do need governments, but their function should be restricted to the minimum necessary to preserve order and freedom.

Question 9.—Should engineers, when they first qualify for entry into the profession, be technically literate enough in their specialty to apply pertinent published research? How much formal education is enough?

Answer.—The complex societal structure which engineers are obligated to serve as professionals requires that they *acquire enough* formal *education* and *experience* to develop their competency as practitioners. Arguments persist as to how much is enough. What may have been adequate even a generation ago may now be regarded as unsuitable, even though new subject material replaced older obsolete topics. Some feel that a 4-yr baccalaureate is sufficient *for entry* into the profession; others favor suitable supplemental experience *for qualification* as a professional; still others suggest that *at least* the masters degree in engineering should be required today *for practice* over the next half century.

Rather than specify a time requirement for entry, it seems more pertinent to require enough education os that engineers will function adequately as practitioners. One important engineering purpose is to design and to produce new products and systems. Since these are invariably based upon new scientific discovereis, it appears reasonable to suggest that engineers be educated formally until they can read and then apply published research findings. Today that would require five or more years of formal study. However, neither the time nor the degree requirement is as important as the academic level reached. That could be verified by proper examining techniques. The educational level could be most easily achieved by resident professional school instruction. However, home or on-the-job study in external degree programs should also be developed here as they have been in England for over 100 yr, and in Connecticut recently with its College Level Education Program (CLEP).

Engineers with a lesser amount of education than that required for technical literacy have frequently been relegated to work as technicians; many others in the engineering spectrum have also pursued rewarding careers as managers rather than as practitioners. managers fulfull an essential role and they may

employ some elements of leadership as they carry out assigned missions. However, the ultimate role of the engineering professional in societal leadership is to participate in the development of technological missions:

Question 10.—Should engineers be required, or merely expected, to continue their education lifelong, and to requalify for practice periodically? If so, how?

Answer.—Regardless of the roles engineers pursue during their active practice, they will need to continue their education. Such self- or guided-study will be easier if it is based upon a broad scientific and cultural base and upon a thorough understanding of all engineering sciences. Competition and pride have usually driven most engineers into such lifelong study heretofore. The future may find them being forced to continue their education to requalify for practice by licensing boards, professional societies, or employers.

It might pay industry and government to consider granting extended educational sabbaticals at universities to some engineers periodically as they do to managers. However, it should also be recognized that, generally, industrial practice leads collegiate classroom instruction. Periodic short courses are perhaps adequate in most cases. These can be effective, provided they are not too concentrated. Lastly:

Question 11.—Should engineering professionals be qualified for practice only by credentialization, or registration, or certification, or licensure? Which?

Answer.—Only professionals have the competence to say what the qualifications should be for entry to their profession. Formal *education may be established by examination*, whereas *experience can only be evaluated*. The criteria for entrance into the several "learned" professions vary from 4 yr–8 yr of collegiate education plus zero–4 yr of experience. At present, those *criteria for licensure* are 7 yr + 0 yr for law, 8 yr + 1 yr for medicine, 4 yr + 2 yr for accounting, 6 yr + 4 yr for architecture, 4 yr + 4 yr for engineering, and 7 yr + 1 yr for the ministry.

Qualification by certification usually involves an examination, as for CPA's and clergy. *Qualification by registration* may require only an application to engage in some specified activity, as for a lobbyist; or, it may include some specified education or experience, or both, as for a registered nurse and a professional engineer. They are really *licensed* and a list of such official registrants is maintained. *Qualification by credentialism* implies that proof of the validity of specified credentials has been verified by some recognized organization, like a college degree by a university.

How engineering professionals should be qualified for practice is debatable. If they aspire to professional status, their qualifications must be recognized by the public. All methods are used now to some extent. The public would be better served and protected if *all* engineers were qualified by only one method. The two most promising would be either licensing by governmental boards (state or federal), or certification by a single engineering unity organization.

Conclusions and Goals

The foregoing discussion described the complex nature of the related issues

that will affect the practice of engineering in the 1980s. It seems suitable to let each engineer study them himself, and to enumerate a few goals and challenges here instead.

The ever increasing acceleration of engineering progress since the industrial revolution began should instill pride and caution in all who do, or who hope to practice. Yesterday's rule of the market place—caveat emptor or let the buyer beware—will no longer suffice. Now, the buyer is aware, and he will demand optimum service by professions, government, and industry.

There can be great hope for the future if the public's interest remains a paramount objective of all three of these societal segments. It is time for a greater team effort and for the development of esprit de corps conducive to professional practice and societal leadership.

Engineering in the 1980s will face exhilarating challenges. Today's novices will design not only skyscrapers but starscrapers as large as cities that will orbit the earth. These will be used to produce exotic flawless materials in zero gravity fields. Engineers of the future will build new transportation systems keeping in mind that they live on the bottom of an air ocean and that the most economical systems energy wise may be those that float through that fluid.

The engineers will also be more careful as they practice to avoid polluting this air or the waters or in scarring the landscape unduly.

Whole new systems of instant communication wait to be developed that will obviate the need for so much business travel, and that will enhance formal and continuing education for all people in even the remotest areas. Hand "calculators" will translate not only the printed word as some do not, but speech directly from one language to another.

New diagnostic systems will be perfected by engineers and scientists for health care. Ultrasonic scanning has already replaced computerized automated tomography eliminating the need for x-rays, but still uses computers. Microminiaturization—a technological fallout of the space program—has just improved surgery by a quantum jump.

The 1980s will continue to witness a diminishing of nonrenewable resources. However, superior substitutes can be as plentiful as innovation, education and motivation can provide. Perhaps the following goals will serve as suitable challenges for the 1980s.

Engineering Goals for 1980's

Goal 1. Restructure formal engineering education so that those entering the profession will be ethically motivated to serve, and eminently competent to practice creatively.

Goal 2. Unify the engineering profession so that it will be better able to assist society and government to select appropriate technological missions.

Goal 3. Provide suitable incentives so that all engineering practitioners will strive to innovate and to enhance their competence by continuing educationor self-study.

Goal 4. Encourage engineers who have a talent for leadership to study its principles, to engage in legislative affairs and to present the pros and cons of technical issues to the public.

Goal 5. Develop a set of professional policies for engineering practice that strengthen the free enterprise system and political freedom, and that replace governmental regulation with professional responsibility.

Goal 6. Develop social mechanisms so that engineering organizations can act as the public's advocate or lobbyist's adversary whenever the public's safety is endangered.

Goal 7. Strengthen existing professional ombudsman's functions of engineering societies to assist engineers if they are ever pressured to engage in unacceptable practice that might endanger the public safety.

Goal 8. Let not education for the engineering profession be regarded as a passport to privilege, but rather as an opportunity to serve.

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Professionalism and Building Systems

By Duane S. Ellifritt,[1] M. ASCE

Introduction

The question of who is more professional, a consulting engineer working directly for a client, or an engineer employed by a large organization, is not a new one. It has been written about and discussed in many publications. However, a new wrinkle to this old debate is emerging. There seems to be a deep rift developing between consulting structural engineers who design buildings for clients, and companies which produce and market standardized building systems designed by in-house engineering staffs. The purpose of this article is to examine some of the current prevailing attitudes and present possible motivations for them.

A recent letter to the editor of the *Engineering News-Record* starts out

> It is interesting to note how quick manufacturers are to shun responsibility and to place blame on the architect or engineer. . . .

Even if you read no further, you would suspect that the letter writer is either an architect or engineer. However, no clue is given as to his motives. He goes on

> If the manufacturers of the prefab buildings whose roofs have been collapsing do not want to be responsible, they should stop trying to sell to the general public. . . .

From the tone of the letter, it might be assumed that the writer has had a bad experience with some kind of manufactured building and is understandably upset about it. It helps to know that this letter was written in response to an article about roof failures in an earlier issue. The writer continues

> They advertise in lay publications and profess to create better and cheaper buildings. The owner, seeing this, does not retain a design professional, but contacts a representative of the manufacturer. . . .

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Now the writer's motive is beginning to come into focus. He concludes, ". . . An owner who wants a building should retain a design professional first, not a prefabricator or a contractor."

The first clue is "design professional" and the second is the "A.I.A." after the writer's name. These contribute much to one's understanding of such a letter. If this were a single isolated incident, it would not merit further consideration, but such an attitude typifies a deeper malaise that afflicts the building industry and may require some rethinking of just what professionalism means. It would be easy to dismiss a letter by an architect who wants to make more work for architects, or whatever his definition of design professional is, as self-serving if it were not for the underlying implication that "professional" rules out working for an employer as opposed to dealing directly with a client.

This letter, then, is important as an example of a disturbing trend. It is another in the growing list of insinuations, most often heard in casual conversation, but sometimes openly expressed in various literary forms, that engineers who work for manufacturing firms designing the products those firms produce are somehow not quite as "professional" as are those engineers who do design work on a contract basis for clients. The former, it is argued, place loyalty to the company above loyalty to the customer and therefore, cannot always be counted on to act in the best interests of the customer. The latter are responsible only to these clients and thus will always act in the client's best interest, so the conventional wisdom goes. This has been the subject of many articles in professional journals and is a popular subject for debates in senior seminars at engineering colleges. It is not the purpose of this article to rehash all the old arguments on this matter, but instead to present a sort of case study in one area in which the conflict seems to be most acute—the design and construction of standardized building systems.

This competition between the engineers who work for consulting firms or are self-employed, and the large manufacturing firm is not present in the production of most consumer products. To the writer's knowledge, there are no self-employed engineers who design automobiles or electric can openers on a custom basis. It seems to be a problem only in the field of standardized building systems, and the disagreement is understandable. The consulting structural engineer is more and more being circumvented by the manufacturer's engineer who designs the system, and so, the common reaction, typified by the quoted letter, is born out of fear as the consultant sees his conventional livelihood being eroded. It is natural then that he should strike out at industrialized building, which is perceived as a movement which may someday render his own skills obsolete. It need not be so, but this is his perception, or so it seems.

Structural Engineers Association of Illinois (SEAOI) Failure Report

That the brotherhood of structural engineering consultants is smarting from this loss of business is apparent in the report of roof failures in the Chicago area in 1979 prepared by the SEAOI and released in November 1979:

> Consensus indicates that the primary type of construction involved in roof failures is that of the wood bowstring truss type roof. The second:

the steel bar joist systems, and third: the metal building systems commonly referred to as pre-engineered buildings.

The report conveniently omitted the actual number of failures reported in each of these three categories. Out of some 150 roof failures in the city limits of Chicago, only two were metal building systems and about ten were of steel bar joist construction. Why did the SEAOI give so much attention to these latter two categories? Read on:

> It is interesting to note that much of the distress resulting from the Blizzard of 1979 was experienced by those construction types that may be considered products, where the control of the design, fabrication, and installation is in the hands of the manufacturer and the producers of the particular construction type.

At the end of the report, the SEAOI wrote a series of "policy statements" for each construction type, with motives of undisguised transparency.

> Manufactured products, such as bowstring trusses, bar joists and metal buildings, should be the responsibility of the product manufacturer. His responsibility should extend both to the engineering and to the quality of the fabricated item. *He should employ the services of a registered structural engineer to aid him in the strength design characteristics of his product.* (Underlining added by the writer).

This is a revealing statement. It tells much about the lack of communication between the engineers who work for systems building manufacturers and those who work directly for clients. The unspoken pejorations here are that engineers of manufactured buildings systems are not "design professionals" or even "professionals"; that they are not free to exercise good engineering judgment if that judgment is not in accord with that of their employers; and that they need help in "strength design characteristics" from a registered structural engineer, presumably one not in the employ of the manufacturer.

An adherent to this line of thinking may point to the National Society of Professional Engineers (NSPE) which has many subgroups, two of which are Professional Engineers in Industry (PEI) and Professional Engineers in Private Practice (PEPP). The society recognizes that there is a difference between these two groups, but there is no implied hierarchy of professionalism, nothing to suggest that one is more less "professional" than the other. The divisions are created because of the activities pursued in the respective categories, not because of differences in honesty, integrity, or compassion for the consumer. So-called "private practice" engineers have no greater concern for the public welfare than "industry" engineers.

Why Conflict?

While there are many diverse means of constructing buildings of standardized, mass-produced, interchangeable parts, by far the most common are those marketed by the manufacturers of metal building systems. Currently, 50% of

all low-rise, nonresidential new buildings are metal building systems. Of the other 50%, a good many are standardized systems of other materials such as precast concrete or timber which generally do not require the services of a consulting structural engineer. The wrath of the consulting engineering fraternity, then, is primarily directed toward this group of manufacturers.

But what is behind it? What is there about a standardized approach to building that provokes an architect to disparage it in the *Engineering News-Record*, and a consulting group to suggest that building systems manufacturers do not have the necessary engineering expertise and therefore, should hire one of them to help out on every job? Why this more-professional-than-thou attitude of so-called "design professionals"? The writer believes there are four major reasons: (1) Economic loss; (2) difference in design philosophy; (3) perception of the state-of-the-art; and (4) unequal fear of lawsuits.

Economic Loss

It should come as no great surprise that building systems, using standardized, mass-produced parts, have become more popular because of the general economic condition. With runaway inflation, only the Federal government can afford to build pyramids; the owner of a small manufacturing business wants to occupy his new building as quickly as possible and that may guide his selection of a building type. As building systems take over more and more of the low-rise market, there is less and less work for the conventional consulting structural engineer, as well as the structural steel fabricator. Watching a past source of income dry up does not make for good relations between consultants and building system engineers employed by manufacturers. (I was once asked by a professor, after speaking to one of his classes, "As a professional engineer, don't you feel a little bit guilty taking jobs away from design professionals?" I gave him the usual build-a-better-mousetrap reply.)

Differences in Design Philosophy

A structural engineer doing a custom job will tend to overdesign it. It is simply a matter of economics; a little extra material is less costly than the engineering or computer time necessary to justify omitting it. Likewise, wasting material to save field labor is usually a good tradeoff. An example is the use of a constant size of all concrete columns in a given story, even though they carry different loads. It's cheaper to use a little more ready-mix than to form several different sizes. There is another factor that influences this design "philosophy," if that is a proper way to describe it. The designer is probably not working against a cost constraint at the time of design. Sure, everyone is interested in keeping costs down, especially the client, but the point here is that the designer is probably not preparing his design for a competitive bid. This situation is changing; the Supreme Court has outlawed the prohibition of competitive bidding for engineering services, but traditional methods of practice do not change overnight. While design services may be competitively bid on some jobs, especially government ones, it is the writer's belief that most structural engineers are already engaged by the client or architect at the time the design is done and thus have no competition for the job. While it may be argued

that the engineer should not be influenced by competition when making a design, he may tend to be a bit more careful about member selection and a bit less conservative, if it means losing out to the low bidder. There is no question that it does put a different coloration on the philosophical question of how close to design to allowable limits.

Samuel Johnson said, "When a man is about to be hanged, it concentrates his mind marvelously." Likewise, when an engineer is about to be underbid, it focuses his attention more intensely on those design refinements he couldn't afford to make in a noncompetitive situation.

A manufacturer's engineer who designs a standardized building cannot afford the luxury of wasting material for two very good reasons: (1) He is designing for mass production; thus extra engineering and computer time can be amortized over many buildings instead of simply charged off against one; and (2) he performs in a highly competitive market. If his design is too costly, he will lose the business to other manufacturers of the same or similar product.

Perception of State-of-Art

A consulting structural engineer must have competence in many areas of design. He may go from bridges to sewage treatment plants to high-rise office buildings and work in concrete, steel, timber, or composites. Broad experience in many areas and depth in none is a characteristic of this person. The building systems engineer is generally more narrowly trained, but has the time and motivation to dig deeper into the behavioral aspects of the one area of competence he does have.

This is one of the major sources of conflict between the two types of structural engineers. The consultant uses the state-of-the-art as set forth in current design specifications; the systems engineer advances the state-of-the-art through research, and it takes several years for the standards used by the consultant to catch up.

The building system is designed by the manufacturer's engineers, fabricated by the manufacturer, and often erected by a contractor who has been trained by the manufacturer for that specific purpose. Because it is a standardized system that will be marketed in mass, the rules of structural design are different from those traditionally learned in college and practiced by independent consultants.

The traditional rules were made by the fraternity of consulting structural engineers and research professors, and are molded to fit one of the common canons in the profession i.e., it is better to waste some material and add a little extra safety than to spend time trying to find out how the member really behaves under load, or, for that matter, what the loads really are. The American Institute of Steel Construction (AISC) Manual, e.g., was made for the custom job; it may not be adequate for industrialized steel building systems.

It is the writer's observation that most consulting structural engineers do not understand this dichotomy. Perhaps, it has simply never been explained to them before. That is one of the motives for writing this article. For them the traditional design specs, the AISC Manual, the American Iron and Steel Institute Cold-Formed Manual, the American Concrete Institute Code are the state-of-the-art. Any design which attempts to go beyond this state is, therefore,

suspect regardless of imposing research support. The fact is that metal building manufacturers have been doing things that traditional design specs said shouldn't be done for 25 yr. The only way these practices can be justified is through research conducted by an independent agency, but even then general acceptance may lag several years behind.

Unequal Fear of Lawsuits

Professional liability insurance for consulting engineers, like malpractice insurance for doctors, has sky-rocketed in recent years. A single individual in business for himself can hardly afford it, yet he is all alone if his design proves inadequate and a failure occurs. It is easy to put the finger on him, so he must cover himself. One way is with professional liability insurance; another way is to use plenty of conservatism in design, drop his liability insurance, and put the house and car in his wife's name. And it is being done.

An engineer working for a building systems company does not feel quite so vulnerable. He is buried deep within a large organization and even if he makes a design error leading to a failure and litigation, it will be his company which will bear the liability, not him. If it happens frequently, he may lose his job, but the cost of an honest mistake will not be borne by him personally. He, therefore, does not feel this "marvelous concentration" that Johnson spoke of and the resultant urge to overdesign everything. On the other hand, the large company is much *more likely* to be sued. Simply being larger and having more money makes a company a more appealing target for plaintiffs.

There are, of course, many architecture/engineering firms that are larger than some manufacturers of standardized building systems. An engineer in the employ of one of these big firms that employ hundreds of engineers may feel more closely akin to a product manufacturer's engineer than a consultant. This doesn't obviate my hypothesis, however. Most consulting firms are relatively small. The American Consulting Engineers Council reports that four out of five firms do not even have in-house computing capabilities.

It is the writer's opinion that the individual consultant or small architecture/engineering firm is much *less* likely to be sued than a company manufacturing standardized buildings, but the consequences may be more painful for the former, and it definitely colors the attitude toward risk and how much is acceptable.

Conservatism, over and above that required by design specifications, is the price being paid by the consumer so the consulting engineer can sleep better at night in our increasingly litigious society, one that Samuel Florman says is "underengineered and overlawyered."

What is "Design Professional"?

Just what exactly is the definition of a "design professional" anyway? As the term is generally used, it refers to an architect or engineer in private practice who deals directly with a client as opposed to one who works for a product manufacturer. The terminology is given credence by such organizations as the National Institute of Building Sciences which uses "design professionals" as one of the 12 categories of membership to insure proper balance on committees. The connotation is clearly the consulting engineer or the architect working on

a retainer to a client. Engineers in industry fall into the category of "producers," "manufacutrers," "trade associations engineers," or several others.

On the other hand, Joe Ward, President of ASCE, is quoted in the April 24, 1980 issue of the *Engineering News-Record* as saying, "As design professionals, we civil engineers see this impact (reference to Carter's tight money policy) on construction first." As used here, the term seems to include all civil engineers in construction, and most of those work for an employer.

There is no mistaking how consulting engineers view the definition, though. It excludes all engineers working for industry or government, even if they are licensed professionals. There is even an architecture/engineering firm in Albuquerque, N.M., called Design Professionals, Inc.

A recent survey of the metal building industry revealed that 453 engineers are employed by the 33 members of the Metal Building Manufacturers Association. Of these, 245 are registered professionals, with all 50 states being represented. In addition, two metal building manufacturers, Butler and Mitchell, have been past winners of the NSPE award for encouraging professionalism within their organizations.

These engineers are "design professionals" who know their product and its performance better than any consulting engineer simply because it is the only subject that concerns them and they have the time and motivation to go to depths in design where the independent consultant, for good reason, does not venture.

Conclusion

A customer who wants a building *should* have access to a "design professional," as the letter at the beginning suggests, but he should have the assurance that such a professional is thoroughly familiar with the type of construction being considered. The customer should also be made aware that many design professionals are employees of building systems manufacturers and this makes them no less professional than the engineers or architects who work on commission for clients.

It is time to put to rest the notion, promoted largely by the latter group and exemplified by the quoted letter, that the term "design professional" is the exclusive property of those who work directly for clients, and that those who don't are simply employees of a manufacturer. It is true that there are differences in design philosophy and technique, but the common meeting ground between the two groups is professionalism and concern for the well-being of the general public. Any engineer who takes his profession's code of ethics seriously could not be otherwise.

The Role of the American Society of Civil Engineers in Influencing Public Policy on Controversial Technical Issues[a]

By Melissa Ruppert[1]

Introduction

When a controversial technical issue faces the public, the citizens must look to experts in that particular field for guidance. The American Society of Civil Engineers (ASCE) is one such group of experts that posesses the power to influence public policy on controversial issues for the most beneficial outcome for society. As civil engineers, the members of this organization have earned the responsibility of protecting, advising, and informing the public to the best of their ability when such issues arise. It is only through active participation in the organization and through a professional concern that civil engineers can effectively realize this responsibility.

Goals of Civil Engineering Profession

The goal of any profession should be to use its expertise wisely in order to serve society. The goal of the civil engineering profession is certainly no exception with its main role in providing leadership, technical knowledge, and skillful judgement required in creating structures and systems which affect public life. The ASCE is the professional organization through which civil engineers have a united voice in serving society. In fact, the organization had adopted the motto "A People Serving Profession" to emphasize its purpose. In fulfilling this objective, one of the important duties of the ASCE is to influence public policy on controversial technical issues resulting in the most effective and beneficial outcome for society.

[a]Zone II Winner 1980 Daniel W. Mead Prize for Students.

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Note.—Discussion open until December 1, 1981. To extend the closing date one month, a written request must be filed with the Manager of Technical and Professional Publications, ASCE. Manuscript was submitted for review for possible publication on April 24, 1980. This paper is part of the Issues in Engineering—Journal of Professional Activities, Proceedings of the American Society of Civil Engineers, ©ASCE, Vol. 107, No. EI3, July, 1981. ISSN 0191-3271/81/0003-0213/$01.00.

Performing As A Professional Civil Engineer

The skill and technical knowledge utilized in performing as a civil engineer is acquired through education, experience, and dedication. Those who master these requisites are professional engineers and are personally responsible to see that technical activities and developments are properly utilized to serve the public. With technical expertise being the tool of the engineer, he accepts the professional and moral obligation to monitor and control its use by speaking out in the public's interest. It is the engineer's duty to keep the citizen's welfare first and foremost in his mind and actions, especially in regard to the ill effects of unsafe and wasteful practices.

Engineers united in a professional organization such as the ASCE can serve as society's advocates when controversial technical issues arise which affect the public's safety and welfare. These professionals are far more capable of comprehending technical subjects than the ordinary citizen, thus, it is the engineer's duty to protect, inform, and advise the public. By accepting this responsibility, the ASCE can play a role in influencing public policy on controversial technical issues.

Role of ASCE

Protect.—Society needs to be informed and protected from hazards that can affect a person's environment, health, or property. The ASCE can be effective by providing assistance to conscientious civil engineers who speak out for the public interest even though such comments may conflict with those of management, special interest groups, governmental agencies, or industries. Engineers need to know that as professionals they have some engineering group to turn to in such a situation. It is the ASCE's duty to investigate the credibility of controversial issues and then take some type of action such as establishing a task force to develop a position on the subject, taking legal action, or bringing the issue into the public view. The organization should be independent enough to undertake these types of action despite any outside pressures which may be applied. By seeking out and acting on issues such as this, the ASCE can be of value to society. The organization will in turn gain the respect and trust of the public, and these qualities are a definite asset when the need arises to influence public opinion.

Inform.—Public communication is another means for the ASCE to utilize in affecting public opinion on controversial technical issues. Communities are dependent upon professionals with technical backgrounds to adequately inform them in layman's terms on controversial issues that concern the well being of the public. Civil engineers, through their professional society, should make their opinions known on topics that deal with their specific areas of expertise. These areas may be water supply, sanitation, city planning, transportation, geotechnical sciences, management, or others. The engineers can fulfill this duty by exercising their communicative skills which they acquired through the process of becoming a professional.

The ASCE's ideas and opinions can be conveyed to the public through various media. Writing articles or letters concerning controversial topics for publication in local newspapers, professional newsletters, magazines, and other publications

is an effective way to reach the public. It would be even more advantageous if these opinions could be written on a regular basis and given a widespread distribution.

Individual civil engineers volunteering on behalf of the professional society to address civic and political groups is another means by which the public can be informed. Members of these groups are usually eager to listen to a professional who is willing to take a position on a disputable issue that may effect the members, their families, and their communities.

It is also the responsibility of the ASCE to alert the public when society has been misinformed or mislead by special interest groups, political action groups, or any group that does not have society's welfare foremost in mind. Civil engineers should do their best to make the public aware by expressing their own ideas, whether or not it coincides with the majority of the people. Engineers have the right to follow their own conscience and form their own opinions. Generally, the citizens of society appreciate it more when they are properly and adequately informed on controversial issues with alternate remedial measures presented to them when necessary. The public image of the ASCE, as a professional organization, will be greatly enhanced through public communications.

Advise.—Civil engineering affects society more directly than any other branch of engineering because its main role is to design and construct those items which affect human lives, health, and property. Projects such as bridges, water and waste water treatment plants, nuclear reactors, dams, and highways are all designed and built by engineers, but these structures are primarily proposed and financed by various governmental agencies. It is usually the government leaders that decide whether or not a certain project is to be funded and constructed. An engineer's influence can become more widespread by personal involvement in the justification of these engineering projects.

Politicians and businessmen deal mainly with people in conducting national, state, or local affairs and making plans for the future. Scientists, on the other hand, are mainly concerned with their research and discoveries and may not necessarily be concerned with the impact that these discoveries have on society. It is the civil engineer who can bridge this gap between technology and the general public. Through educational training and experience in serving the public, the professional civil engineer is knowledgeable on both of these aspects; therefore, the civil engineer can utilize this expertise and exert his influence by volunteering for public office at all levels of government. This would afford the civil engineer a means by which to use his expertise to properly inform, protect, and advise the public on controversial issues. The ASCE should encourage and support, either financially or morally, those engineers who do seek and hold elected governmental positions.

Members of the ASCE can also contribute to the improvement of society by acting as advisors to political dignitaries. Legislative bills that concern both the engineering field and public welfare should be thoroughly discussed by a committee of concerned members. In turn, they should express the organization's opinions and make recommendations to those who are in positions to make policy decisions by writing letters and conversing with government leaders. For example, in the case of the extremely complex Alaska lands issue which concerns the use of the lands of that state, the Louisiana Section of the ASCE

did correspond to the Louisiana delegation in Congress on its position on the subject. There was also reference made to a similar problem of the Atchafalaya River Basin in Louisiana. The basic idea behind these actions, as well as presenting the viewpoints of the organization at governmental and other public hearings, is to effectively advise government leaders on technical matters in order for them to make a more rational decision with their votes. Furthermore, the ASCE should initiate legislation when necessary to help meet the needs of society such as the reformation of registration laws so the laws will protect both the public and the profession. In addition, mayors, city councilmen, and other officials should know that they can count on the civil engineers for unbiased opinions and counsel on pressing national, state, or local problems.

Conclusions

It is the voluntary work of the professional members of the ASCE that contribute to the organization's strength and recognition. Civil engineers should become active in their professional societies to work toward effectively influencing public policy for the safest, smoothest operating, and most economical outcome. With today's growing problems concerning energy, environment, and natural resources, the ASCE has an even more important role than before to aid the public. The organization should increase its efforts in influencing public policy, but this requires an increased effort on the part of the individual members. The ASCE has a duty to participate as much as it can in protecting, informing, and advising society on controversial technical issues because civil engineering is "A People Serving Profession."

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DISCUSSION

Note.—This paper is part of the Issues in Engineering—Journal of Professional Activities, Proceedings of the American Society of Civil Engineers, ©ASCE, Vol. 107, No. EI3, July, 1981. ISSN 0191-3271/81/0003-0219/$01.00.

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Discussions may be submitted on any Proceedings paper or technical note published in any *Journal* or on any paper presented at any Specialty Conference or other meeting, the *Proceedings* of which have been published by ASCE. Discussion of a paper/technical note is open to anyone who has significant comments or questions regarding the content of the paper/technical note. Discussions are accepted for a period of 4 months following the date of publication of a paper/technical note and they should be sent to the Manager of Technical and Professional Publications, ASCE, 345 East 47th Street, New York, N.Y. 10017. The discussion period may be extended by a written request from a discusser.

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Discussions have a specific format. The title of the original paper/technical note appears at the top of the first page with a superscript that corresponds to a footnote indicating the month, year, author(s), and number of the original paper/technical note. The discusser's full name should be indicated below the title (see Discussions herein as an example) together with his ASCE membership grade (if applicable).

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Figures supplied by the discusser should be designated by letters, starting with A. This also applies separately to tables and references. In referring to a figure, table, or reference that appeared in the original paper/technical note use the same number used in the original.

It is suggested that potential discussers request a copy of the *ASCE Authors' Guide to the Publications of ASCE* for more detailed information on preparation and submission of manuscripts.

Responding to the Challenge of Engineering Practice[a]

Discussion by Michael Spero,[9] F. ASCE

Ackerman has written a number of articles on dissent, published in the various engineering journals, since 1960. His 1966 paper, "Water Resources Planning as a Tool of the New Despotism," is one that is worth reading and rereading by every civil engineer. It presents some of the best of ethics an engineer can follow.

In 1960, Ackerman, as a member of an official Board of Consulting Engineers retained by the State of California, became a minority of one when he wrote his dissenting opinion, stating that the California Feather River Project would not be adequately financed. As if to underscore this 1960 opinion, the California legislature recently approved a bill authorizing $5,000,000,000 in general obligation bonds for additional facilities for the state water project, including the Peripheral Canal.

Reading Appendix III of the Ackerman paper brought to mind the following letter from the California Department of Water Resources as published in *Civil Engineering* in October 1964 (p. 66):

An Outstanding Example of Planning Water Needs

To The Editor: With reference to Mr. Ackerman's article, "Using Engineering to Enslave You," in the July issue (p. 67), it is necessary to correct two impressions he left with the reader.

He refers to a state water project without identifying it specifically. He must have in mind the State Water Project of California, approved by the voters of that state in November 1960 and now well along in construction. Mr. Ackerman refers to the voters' assuming "vast financial commitments" as taxpayers and implies that the State's credit position will be impaired by bond financing of the two-billion-dollar under undertaking.

The State Water Project is self-liquidating, without cost to the taxpayers of the State. Project revenues from the contracted sale of water will retire, with interest, the bonds issued to finance construction. The State's credit has been strengthened rather than weakened by the issuance of the water bonds. The first two issued—totaling $150 million—carry interest rates of slightly over 3.5 percent, well below the 4 percent used in computing project feasibility. Further, the concensus of the financial community is that these returns compare very favorably with the rates ordinarily obtained on sale of other General Obligation Bond issues.

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[a] April, 1980, by Adolph J. Ackerman (Proc. Paper 15374).

[9] Retired Civ. Engr., 8390 Winchester Circle, Boise, Idaho 83704.

Mr. Ackerman may have reason to doubt the adequacy of planning for some long-range engineering projects, but California is not to be included in such a broad generalization. The California Water Plan alone, published by the State's Department of Water Resources in 1957 as its Bulletin Nol 3, is an outstanding blueprint, designed to meet the State's growing needs. It is a master plan of which all civil engineers can be proud.

(Name withheld)
Chief Engr., Calif. Dept.
of Water Resources

Sacramento, Calif.

The history (38,40) of the past 16 yr has clearly exposed the errors and misrepresentations advanced in this letter:

1. The State Water Project of California, as approved by the voters of that State in November, 1960, was then known as the Feather River-Southern California Aqueduct Project. The money authorized by the voters, $1,750,000,000, has been spent, along with a major overrun. Yet the project remains uncompleted because of the successful efforts of the people in the northern counties in preventing the construction of the Peripheral Canal, the missing link around San Francisco Bay. Petitions calling for another referendum on the November 1980 ballot, in opposition to the Peripheral Canal, are being circulated among the registered voters in the bay area.

2. The record is now clear in exposing the fallacy and public deception in the claim that this project "is self-liquidating, without cost to the taxpayers of the State." This same record has also disproved the claim that "project revenues from the contract and sale of water will retire, with interest, the bonds issued to finance construction." In turn, it is an historic fact that the State's credit has been seriously damaged by the issuance of the water bonds.

3. How many people understand the vast difference in state financing between "revenue bonds" and "general obligation bonds?" The Water Plan is being financed with general obligation bonds and thereby is creating heavy increases in state taxes. This has led to a statewide taxpayers' revolt which culminated in June 1978 in the sweeping passage of Proposition 13 for a cutback in taxes (39).

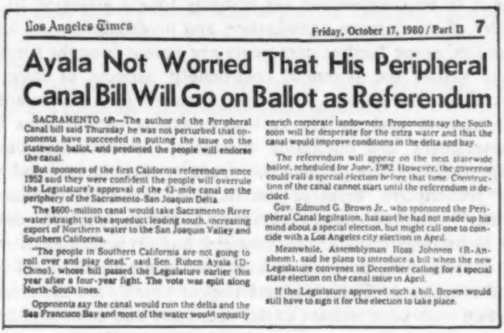
4. The experiences of the past 16 yr have disproved the claim that the State Water Plan is "a master plan of which all civil engineers can be proud."

When Mr. Ackerman writes "Engineers, Speak Up! Speak Up!, he should follow it with—"Listen to Us! Look Around Us!" Why look around us? Because, no people, anywhere, or at any time in history, have been able to live out their own lives on their own terms. Entire civilizations have been overwhelmed and destroyed by what was happening around them (4).

This latest news item (Fig. 2) turns the spotlight on the Peripheral Canal, the unfinished part of the Feather River-Southern California Aqueduct Project. During the past 18 yr, the people of northern California have shown strong reasons for stopping the construction of this canal. In the meantime, the rest of the project has been built and more than $2,000,000,000 of the taxpayer's

funds have been spent. A new referendum on building the canal and authorizing another $600,000,000 is scheduled for June, 1982. To date there has been no income and no repayment on this project from the sale of northern California water to the Los Angeles Area. This explains why informed engineers, including myself, are not proud of this project. The Commonwealth Club of California has reports and records of hundreds of hearings and a considerable number of studies it has made on the California Water Plan going back as much as 25 yr. Literally, a substantial number of the most highly regarded professional engineers in the bay area have been in the forefront of all the criticism directed against the California Water Plan in open forum.

Rain to river to ocean, and back to rain; within that cycle water is in our custody for our use and for our advancement. None of us owns it. It will remain after we are gone. But if we misuse it, or fail to resolve our human conflicts, then we are violating our constitutional system of government and serving the cause of The New Despotism. The choice is ours to handle water properly or to damage ourselves and future generations. If the Peripheral Canal



Los Angeles Times Friday, October 17, 1980 / Part II 7

Ayala Not Worried That His Peripheral Canal Bill Will Go on Ballot as Referendum

SACRAMENTO (AP)—The author of the Peripheral Canal bill said Thursday he was not perturbed that opponents have succeeded in putting the issue on the statewide ballot, and predicted the people will endorse the canal.

But sponsors of the first California referendum since 1952 said they were confident the people will overrule the Legislature's approval of the 43-mile canal on the periphery of the Sacramento-San Joaquin Delta.

The $600-million canal would take Sacramento River water straight to the aqueduct leading south, increasing export of Northern water to the San Joaquin Valley and Southern California.

"The people in Southern California are not going to roll over and play dead," said Sen. Ruben Ayala (D-Chino), whose bill passed the Legislature earlier this year after a four-year fight. The vote was split along North-South lines.

Opponents say the canal would ruin the delta and the San Francisco Bay and most of the water would unjustly enrich corporate landowners. Proponents say the South soon will be desperate for the extra water and that the canal would improve conditions in the delta and bay.

The referendum will appear on the next statewide ballot, scheduled for June, 1982. However, the governor could call a special election before that time. Construction of the canal cannot start until the referendum is decided.

Gov. Edmund G. Brown Jr., who sponsored the Peripheral Canal legislation, has said he had not made up his mind about a special election, but might call one to coincide with a Los Angeles city election in April.

Meanwhile, Assemblyman Ross Johnson (R-Anaheim), said he plans to introduce a bill when the new Legislature convenes in December calling for a special state election on the canal issue in April.

If the Legislature approved such a bill, Brown would still have to sign it for the election to take place.

FIG. 2.—Notice on Peripheral Canal Bill (Los Angeles Times)

is built and goes into operation, will salt-water intrusion from the ocean destroy the present fresh-water San Francisco Bay?

Ackerman's paper provides a fresh look at the guidelines of human conduct and professional standards of behavior for engineers. He has defined specific areas of conduct; other important areas of conduct related to engineers are implied but not mentioned specifically. Most importantly implied is:

> It is not what interpretations others may make with respect to conduct or what others may do; but, for each professional engineer from his own conscience to determine the limits of the bounds of propriety and the right.

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Earthquake Prediction: A Socioeconomic View[a]

Discussion by Sridhar J. K. Rao[3] and James Day[4]

The author is to be commended for bringing timely attention to an area of concern worthy of much more examination and investigation. As an extension of that discussion, some further comments are herein brought forth. A recent study by Paté shows the potential cost-benefit aspects of investments on earthquake prediction which the author recommends (15). There are a number of interactive aspects such as: (1) Various emerging technologies for seismic prediction, assessment, and mitigation measures; (2) continuing developments in engineering planning, design and construction techniques, and procedures varying from "prescriptive" oriented specifications based on previous experience to "performance" oriented codes of practice based on research, development, and effective technology transfer mechanisms; and (3) institutional mechanisms for planning, coordination, decision making, and implementation of seismic risk prediction and mitigation. These aspects impact heavily on different levels of hazard mitigation with concomitant costs, economic and environmental effects, and design of public policy measures in terms of effective implementation mechanisms and institutional design for coordination, effectivensss and performance. The author has rightfully emphasized the importance of both the engineering and institutional coordination aspects of seismic hazards.

There is no doubt that earthquake prediction technology will play an important role in reducing losses from future earthquake events, once the prediction technology has reached a reliable and consistent level of development with sufficient accuracy considering the uncertainties of the overall problem. However, regardless of the precision with which an earthquake event is predicted, the contribution of prediction technology to minimize the overall impact of a seismic event is limited. Seismic prediction as contrasted to seismic mitigation and earthquake engineering can, at best, only be an important portion of a broader seismic safety program, in as much as knowing when a seismic event will occur in a region is only, at best, a part of mitigating the consequences of that event. Although there has been significant progress in earthquake engineering design and codes of practice, there is a need for developing realistic performance

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[a]July, 1980, by John H. Sorensen (Proc. Paper 15550).

[3]Prof. of Civ. Engrg., California State Univ., Long Beach, Calif. 90840.
[4]Grad. Student, Dept. of Civ. Engrg., California State Univ., Long Beach, Calif. 90840.

oriented codes of practice for evaluation of existing structures for various levels of seismic hazards in terms of damage, life safety, cost-effectiveness of various mitigation measures, and problems of coupling of earthquakes with subsequent disasters (such as fires, tornadoes, etc.). This needs integration of knowledge of dynamic and cyclic behavior at material, member and structural levels considering actual structures rather than very idealized equivalent static models which do not take into account the complex structural effects and interaction with foundations, nonstructural elements, utility, and other service features. This would entail a significant addition of "structural systems" approach in a systemic sense and a multidisciplinary engineering-economics-public policy approach to seismic hazards mitigation. What is needed is to develop a systems framework for integrating information being developed under various specializations constituting the problem focused field. Thor Heyerdahl, a noted literary figure states the importance of horizontal integration, thus:

> in order to penetrate even further into their subject, the host of specialists narrow their field and dig deeper and deeper till they can't see each other from hole to hole. But the treasures their toil brings to light they place on the ground above. A different kind of specialist should be sitting there, the only one still missing. He would not go down any hole, but would stay on top and piece all the different facts together

The present development of codes of practice for earthquake resistant design is geared towards new structures and tend to be on the conservative side so as to develop simplified engineering calculation methods aided by judgement to design for damage reduction and life safety by a combination of prescriptive and performance oriented specifications.

In terms of seismic prediction (as the author brought out) seven potentially destructive earthquakes have been successfully predicted in China and the Soviet Union. This is no doubt a notable accomplishment, yet in attempting to apply these results to a democratic, capitalistic society, some subtleties exist. A totalitarian regime would be more conducive to maximizing the utility associated with seismic predictions, because of less resistance and less obstacles to the development and implementation of prediction technology. Economic losses resulting from inaccurate or unreasonably imprecise preductions, which may be inevitable, may be borne directly by the state with virtually no litigation involved. Such a situation in a democratic society would, obviously, not be the case. Legal implications, along with the potential direct and indirect economic losses and other secondary impacts associated with inaccurate predictions would introduce a factor that could seriously lessen the utility of prediction technology unless it is matched with realistic codes of practice or performance oriented assessment of existing structures. In a democratic, interactive society the net utility of a seismic safety program can only be maximized when its numerous parameters are in balance with the complexities of such a society. Inevitably, the seismic safety program itself must be correspondingly complex with each of its component parameters playing a balanced rather than dominant role. Prediction technology, therefore, can only be a part of a rational seismic safety program.

In order to minimize seismic risk, a seismic safety program should at least include the following items: (1) Identification of the sources of severe seismic potential, i.e., active faults; (2) identification of structures that would be damaged during a seismic event (resulting in a retrofitting program for the most hazardous structures) and setting priorities, as the author so rightfully pointed out; (3) provide warnings or predictions of impending earthquakes to reduce hazards from structures which remain; (4) identify and provide warning for hazards which can result from earthquakes and are not due to man-made structures, e.g., land-slides, tsunamis, soil liquefaction, floods, fire, etc.; (5) provide for public education programs and on-going studies for safe structural design; and (6) provide options for legislation of standards for future building and site safety (14). Additional parameters would include training and certification of professionals involved with seismic safety to insure a reasonable level of competence; "state of the art" design for critical facilities and utility "lifelines"; planning and land use controls; emergency preparedness, and post-earthquake recovery planning (16). Such a broad based seismic safety program is necessary in order to substantially reduce the risk of a seismic event.

The engineering evaluation techniques for existing buildings whether after a seismic prediction or as a result of government laws, ordances constitute presently available methodology for the natural hazards evaluation of existing buildings (13). It provides an approximate model to identify structures that would be damaged in varying degrees for various seismic events. After determination of the expected damage levels for the various structures response to seismic events, rehabilitation/retrofit program to strengthen these structures as desired can be developed. In the development of such a program, a balance between the construction costs and the equivalent expected annual cost of earthquakes should be attained. Thus, the economically acceptable level of risk consistent with concern for life, which should be tolerated from a particular seismic event, can be obtained. In the development of such a program, however, it should be noted that not only will this acceptable risk level be sensitive to the accuracy of the developed statistical information, but it will also be greatly influenced by the determination of the party that actually bears the costs of the disaster. Currently there is a liberal system of disaster relief subsidized by the Federal government where a combination of grants and low interest rate loans are provided to individuals who suffer home or business losses. This type of Federal emergency disaster aid policy suggests that the public feels some degree of responsibility toward helping victims of natural disasters. The increasing costs of these disasters also indicates that preventive action is justified from an economic standpoint. The challenge lies in developing a policy which strikes a balance between satisfying the objectives of the individual living in a hazard-prone area and the general public (11,12).

In summary, in order to mitigate the effects of disastrous seismic events, and reduce the amount of potential damage and disruption, a rational, broad based seismic safety policy must be formulated. In order for such a policy to be effectual, it must integrate both horizontally and vertically the capabilities of numerous technologies, rather than rely upon a few. Of equal importance to the formulation of such a policy, is the implementation of such a policy. It is apparent that a successful implementation of such a seismic safety policy can only be realized after existing Federal Relief program policies have been

modified and put into a corresponding balance with the objectives of these local seismic safety policies.

Acknowledgments.—This research discussion paper is based on an ongoing study on a project, "Earthquake Hazards: Technology, Economics and Public Policy," which is supported by California State University, Long Beach, Calif.

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